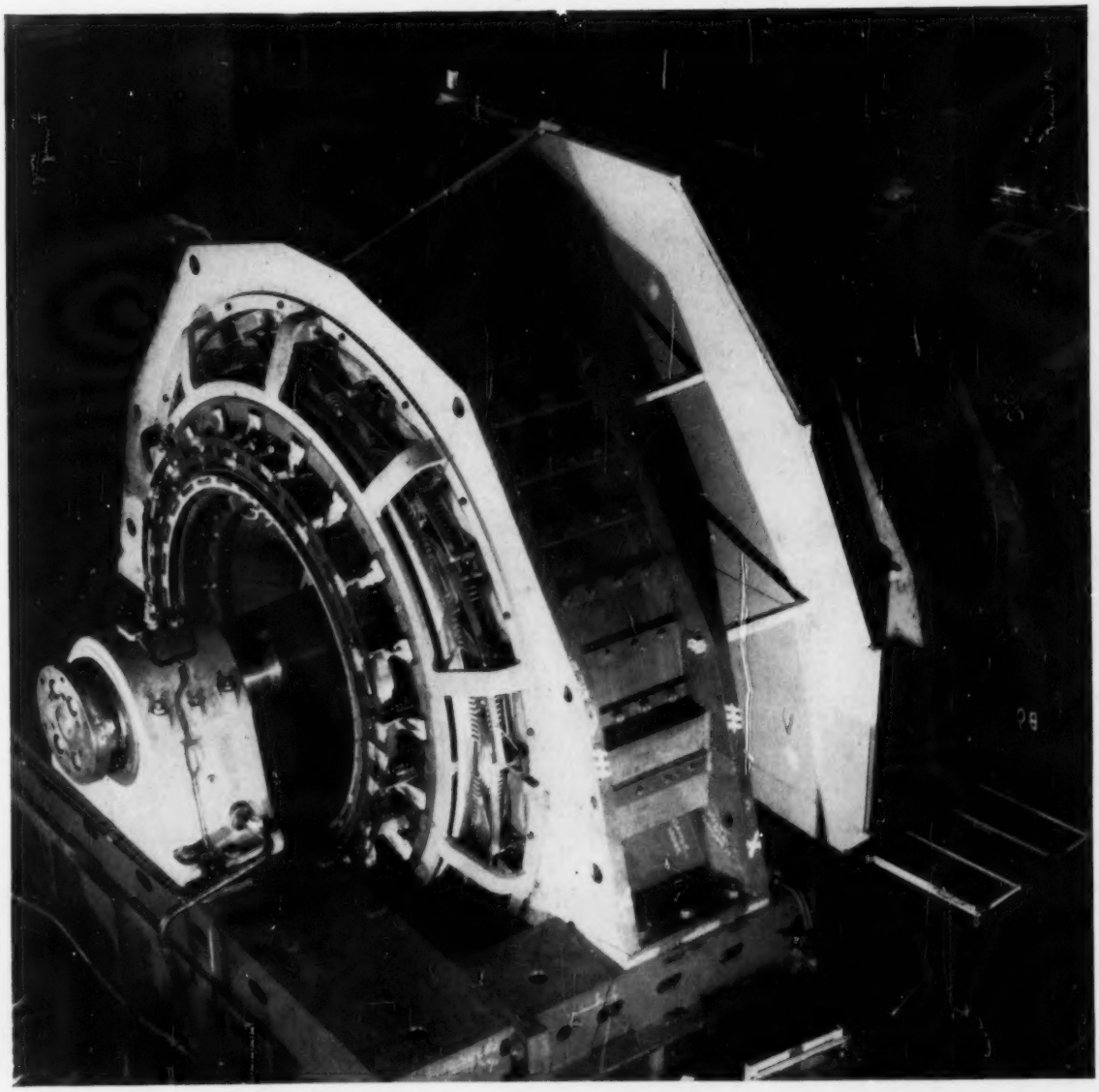
THE BEAMA JOURNAL

FEBRUARY 1961



Two 6 000 h p mine winding motors for South Africa

A QUARTERLY REVIEW OF
BRITISH ELECTRICAL AND ALLIED ENGINEERING

Special Feature in this issue: Domestic Appliances

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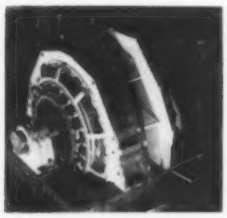

Cover Illustration. *The two 6 000 h p motors, shown on test at the Stafford works of The English Electric Co Ltd, are for the West Driefontein and Doornfontein mines of Goldfields of South Africa Ltd. They are believed to be the largest converter-fed winders in the world and the first to operate on a very high voltage system. The converter transformers will be directly connected to the 40 kV grid*

Editor: **John Dyer**

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A QUARTERLY REVIEW OF BRITISH ELECTRICAL AND ALLIED ENGINEERING

Volume 68 : Number 1 : February 1961

The BEAMA: 1911-1961

This year marks the Golden Jubilee of the British Electrical and Allied Manufacturers' Association—more familiarly known to its friends both in Britain and overseas as The BEAMA.

Fifty years represents the major part of the whole lifetime of the British electrical industry, which may be said to have started about the year 1880, when there began to be an economic use for generating machinery following the development a year or two earlier of small arc lighting sets which could supply a bright and reasonably steady light capable of illuminating railway stations, streets and public buildings.

The design and construction of electrical generating machinery had, of course, quite a long history before 1880, beginning with Faraday's fundamental discovery of the principle of generating electricity by mechanical means and continuing with many subsequent inventions and developments which stemmed directly from Faraday's work and which embodied the fundamental principles of modern generating equipment.

Thus it seemed that Great Britain was well placed to take the lead in the development of a new industry based on this new form of power. Supply systems were growing up all over the country. With the introduction of the incandescent lamp, the commercial field broadened to include lighting sets for ships and theatres, and the house-to-house distribution of electricity supplied from small power stations. Public interest was growing rapidly, and capital began to flow quickly into the manufacturing companies and into the newly-formed supply undertakings.

Then for the first time—and not unfortunately the only time in its subsequent history—the industry became the victim of short-sighted legislation in the form of the Electricity Act of 1882, which retarded the rise of this new industry by imposing severe limitations on companies formed to supply electricity and by localising its generation and supply in the hands of small companies and in many cases of municipalities.

The effect of the Act from the purely technical point of view was not as serious as it might have been, but from the economic and commercial point of view it could have been well-nigh disastrous. An amendment to the Act of 1882 was passed in 1888, and the supply industry in Great Britain began to revive, but British manufacturers were still hampered by many difficulties. For example, they could not effectively compete with manufacturers overseas because the latter were organised in large units and consequently had undoubted economic advantages in tendering, and because British manufacturers, owing to the retarded development of electricity supply, had no adequate and assured home market. Furthermore, specifications for generating and transmission equipment were drawn up by a large number of different authorities. Compliance with differing specifications led to still greater difficulties in standardising design and manufacturing processes, and this in turn had an adverse effect on the possibility of quoting competitive prices.

This brief résumé of the early history of the industry provides the reasons for the establishment of The BEAMA in 1911—and by inviting comparison with the world leadership achieved by the industry in recent years, it also provides the justification and fulfilment of the Association's work during the first 50 years of its existence.

Its justification is, quite simply, the fact that the industry, with the help and guidance of its trade association, has been able to reap the benefits of the engineering ability of member-firms. The fact that The BEAMA was from its beginning an entirely voluntary and co-operative organisation has meant that its work could be conceived and carried out on broad and far-sighted lines.

Formed initially to foster and to protect the interests of the electrical and allied manufacturing companies, The BEAMA has helped to give to the whole of the electrical industry a sense of unity through a common policy of progress for the mutual benefit of the manufacturer and of the user of electrical equipment.

In its Golden Jubilee year, The BEAMA is entitled to say that it has reached a stage when it has provided a stimulating, steadying and constructive influence on electrical manufacture and has become a co-ordinating factor in all the problems connected with the generation, transmission, distribution and utilisation of electricity, upon the right solution of which depends the industrial welfare of the nation.

Railway Electrification

For some months the British Government has been reviewing the organisation and financial problems of the nationalised transport undertakings and this unfortunately has resulted in uncertainty about the future rate of capital investment in railway modernisation in the United Kingdom. The Government's recent announcement that the large-scale London-Midland electrification scheme is to go ahead as quickly as possible was welcomed therefore by the railway equipment industry as a whole, and will undoubtedly also give impetus to the industry's important overseas trade.

In making the announcement, the Minister of Transport (Mr Ernest Marples) expressed the Government's faith in railway modernisation and its confidence in the British electrical manufacturing industry. The manufacturers and contractors fully support the British Transport Commission's estimate that the scheme can be completed by 1966, and the technical, manufacturing and constructional resources are available to achieve this target.

Some reports from overseas suggest that there has been confusion between the question of the rate of capital investment in relation to the finances of the transport undertakings, and the temporary technical setbacks which occurred on two of the newly electrified systems. The Government's demonstration of its complete confidence in the British electrical and allied industry should dispel any misunderstanding.

British manufacturers have an unrivalled experience of railway electrification schemes under widely varying conditions in many parts of the world. It must be remembered, however, that British Railways and the manufacturers, working in partnership, are engaged in the introduction of railway electrification schemes in the United Kingdom employing the most advanced techniques under conditions which are not paralleled in any other country. The new high voltage a c system has been adapted to British Railways with its densely trafficked suburban and main line services, heavy pollution conditions and special clearance problems in tunnels and station areas. More than 600 miles (966 km) of lines have been commissioned on the high voltage system in two months.

The experience gained and the solution of problems which have occurred in applying the system to the special and complex conditions of the United Kingdom will be of unique benefit to the industry in the years ahead.

Trade Between Britain and Western Germany

The presence at the 1961 Cologne Fair of a large collective exhibit of British electrical domestic appliances provided the opportunity for an important statement by Mr Stanley F. Steward, Director of The BEAMA, on the interchange of trade between the U K and Western Germany.

Speaking at a reception on the British stand on the eve of the opening of the Fair, Mr Steward said that industry could give a lead to Governments in promoting the free flow of international trade. He went on to say:

> 'There are numerous matters, including the development of international safety standards and methods of approval, in which industry must take and is taking the initiative. British electrical manufacturers have close and long-standing links with the electrical industries of Western Europe and we attach great importance to strengthening those links by playing an active part in European organisations representing the engineering industries.'

Mr Steward said that The BEAMA regarded the development of international standards as an important priority in promoting trade. The Association had emphasised to its representatives on international standards committees that the industry's policy was governed by the will to reach agreement and willingness to effect reasonable compromise with other participating countries.

There was a growing spirit of co-operation between electrical manufacturers throughout Western Europe over a wide range of technical and commercial matters. The electrical and mechanical engineering industries of the 13 countries of Western Europe had been brought together and were working closely and effectively through ORGALIME (Organisme de Liaison des Industries Métalliques Européenes) in which there were now no barriers between the 'six' and the 'seven'. Mr Steward believed that by this kind of co-operation and by continuing improvement in manufacturing efficiency much could be done to alleviate the effects of the tariff changes resulting from the Common Market.

In all this activity Britain and Western Germany had a mutual interest. While both countries had important electrical industries and an expanding home market, there was also a substantial interchange of trade between them. Western Germany was Britain's best single customer for small washing machines, and was among the ten best customers for electrical products of all kinds. At the same time Western Germany supplied about one-fifth of the electrical goods imported into Britain. Mr Steward added:

> 'This confirms that our two industries are in many ways complementary and each country has something to offer the other, to the benefit of both. It is because of our conviction that this interchange of trade will continue and expand that The BEAMA is marking its 50th anniversary with the Jubilee display at Cologne, representative of some of our leading manufacturers in the domestic appliance field.'

In recent years domestic appliances have formed one of the fastest growing sectors of the electrical industry in Britain, where nearly 800 000 people are employed in all branches of the industry. Output of domestic electrical appliances has been doubled in five years and exports of these goods from the United Kingdom have increased by 27 per cent in the past year to nearly £33 million (389·4 million DM). They represent about 11 per cent of the total exports of British electrical products.

The collective British exhibit at the Cologne Fair (in Hall II, Stand No 2420/2325) is the largest collective display of British domestic electrical appliances yet staged in Europe.

The wide range of products shown by nine of the leading British manufacturers is reviewed in a special illustrated feature on pages 14 to 19 of this issue.

Vibration and Noise in Transformers

REPORT ON A FERRANTI RESEARCH PROJECT

EXTENSIVE research has recently been undertaken by Ferranti Ltd into the causes of transformer noise—a condition which frequently presents problems to electricity supply undertakings, especially where substations and distribution transformers have to be sited in or near centres of population. Housing the transformers in brick-built structures, or the erection of brick baffle walls to contain or deflect the noise are at best only palliatives; they also involve the supply authorities in additional costs.

As part of their overall core research and development programme, Ferranti Ltd have for several years carried out a comprehensive series of noise tests on all types and sizes of transformer cores, as well as on completed transformers, and the results of this work have now been summarised and presented in an extremely ingenious film. By a clever combination of animation and direct photography, the film portrays very clearly what goes on inside a transformer core and thereby creates the conditions which give rise to transformer noise.

The following notes given some indication of the ground covered by the film and the results to date of this interesting research project.

Noise levels are expressed in decibels (db), and in the case of transformers it is usual to use a 40 db weighting network. All measurements were made with a sound level meter comprising in general a microphone, an amplifier incorporating the weighting networks, and an indicating meter.

With the transformer energised on its normal tapping, a large series of readings was taken at a distance of 1 ft (30·5 cm) from the transformer tank and at reference points not less than 2 ft (61 cm) nor more than 3 ft (91·4 cm) apart. The arithmetic mean of these readings gives the 'average surface noise level' of the transformer.

One result of this work was the introduction on September 1, 1960, by agreement between The British Electrical and Allied Manufacturers' Association (The BEAMA) and the British Electricity Boards, of a noise specification which limits the permissible noise level of transformers.

This, however, deals only with results; the main purpose of the research was to ascertain what causes the noise in the first place.

As the film makes clear, practically all the noise emanating from a transformer arises in the core, which vibrates in a complex manner because of the magnetostriction effect of the silicon steel and mutual repulsion or attraction of the laminations.

Magnetostriction is the relative change of dimension of a material in the direction of magnetisation and this change can be either positive or negative. The polarity of the magnetic field is immaterial, the positive and negative half-cycles of current and the magnetic fields which they produce having the same effect on the core shape. With increasing flux density, the magnetostriction will in general increase, but may in some instances reverse. The magnetostriction varies throughout a batch of nominally identical material and even throughout a single sheet. It can be of the order of a few parts in a million and its frequency is normally twice the excitation frequency.

Mutual attraction occurs between adjacent laminations when flux passes from one to the other, and repulsion occurs when flux leaves or enters two or more adjacent plates simultaneously. As the maximum effect occurs at maximum flux, these phenomena also take place twice per flux cycle.

Thus there are two effects causing vibration with a fundamental frequency of twice that of the flux cycle and hence of the supply frequency, *i e* a transformer core working on the normal 50 c/s supply changes its shape at a frequency of 100 c/s.

The total effect is a very complex vibration pattern as shown in Fig 1.

Thus, in transformer cores of hot or cold rolled steel, magnetostriction gives rise to a cyclic change in the length of the leg and yoke. Moreover, there is a flapping motion of the laminations where flux leaves and enters at the joints or other places where a change of permeability causes this transfer.

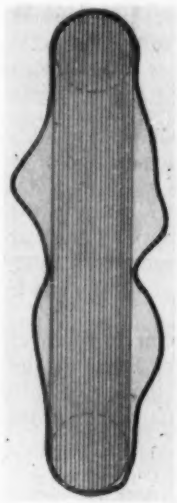


Fig 1.
Diagram showing the relative values of longitudinal and transverse vibration of core laminations

There is also another effect taking place in the individual laminations. This is either a change of permeability from place to place, which causes the flux density and therefore the magnetostriction to change, or a lack of uniformity of the magnetostriction within the sheets, which gives rise to a buckling or writhing motion.

Some indication of the non-uniformity of a sheet of grain oriented cold rolled steel is given by Fig 2, which shows the variation in crystal size of a core plate. Fig 3 shows the variation in magnetostriction in sheets up to 11 ft (335 cm) long and 2 ft 2 in (66 cm) wide. These sheets were cut up into Epstein-sized-samples (28 by 3 cm plates) and each sample was measured for magnetostriction.

In the photograph, the darkest areas represent a magnetostriction constant of 30×10^{-6}, and the white areas a constant of zero. There are other additional factors which may be of importance, such as the motion at a corner where leg

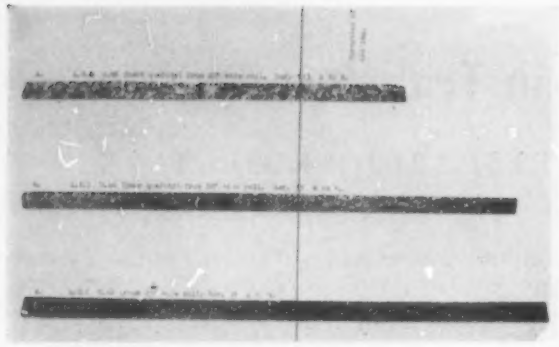


Fig 2.

Crystal distribution in etched pieces of core iron

and yoke in effect collide, and the buckling of a leg or yoke considered as a strut, due to the stress caused by its extremities being accelerated with respect to the centre.

All these motions are very small compared with the size of the core (measurements taken on a 60 MVA core show r m s displacements of the order of 0·0001 inch (0·00254 mm)), but nevertheless they produce the noise associated with transformers. The sound level generated depends on many factors and in general increases with the size of transformer and flux density.

The factors causing vibration are analysed in the film and can be summarised as follows:

1. Longitudinal vibrations—due to pure magnetostriction.
2. Transverse vibrations—due to:
   (*a*) factors of design which cause flux transfer from plate to plate.
   (*b*) variations in permeability from place to place in laminations.
   (*c*) variations in magnetostriction from place to place in laminations.

Methods of Reducing Noise

(i) *At Source*

It will be realised that of the above factors only 2(*a*) is in the hands of the transformer designer, and it is possible to eliminate flux transfer from plate to plate. The other factors, however, are related directly to the steel manufacturing process, and while a material having zero magnetostriction can be made by the addition of about 6 per cent of silicon, it is too brittle for practical use.

To try to prevent vibration by sheer brute force of constraint is not very practicable, as the forces set up in the core are large. For example, in the leg of a 10 MVA core of, say, 150 sq in (968 cm²) area, this force could amount to 12 000 lb (5 443 kg).

(ii) *Reduction of Transmission from Core to Tank*

If the longitudinal vibrations were uniform, the centre of the core leg would be a nodal point with no vibrations. If, therefore, the core could be supported from this point, there would be minimum direct transmission to the tank. This method was tried in the 'Backbone' core described in this article.

It is shown in the film, however, that the vibrations are so complex that this nodal point is ill-defined or even absent. In practice, the reduction in noise transfer is disappointing. Improvements in the uniformity of the core material will increase the value of this construction.

Even if the nodal support were to eliminate entirely the transmission of vibrations through the supports, the parallel path through the oil is left unrestricted. There may be some reduction owing to the presence of windings but, as oil is a 'non-compressible' medium, the core vibrations will be transmitted to the tank walls which in turn will radiate them into the surrounding air.

(iii) *Reduction of Noise Radiated from Tank*

Tank design obviously plays a part in the amount of sound power radiated. Evaluation, however, is by no means simple as the vibrations measured from place to place along the tank walls are of different amplitude and phase.

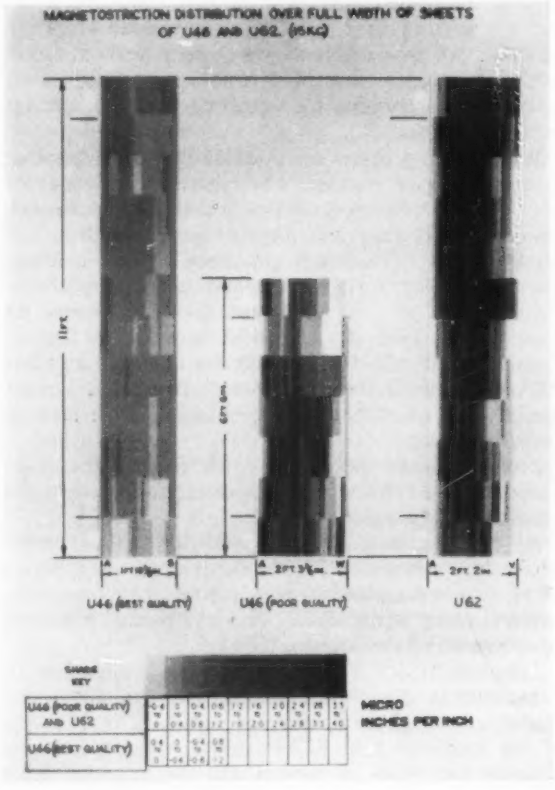
If the tank or any of its components of a 50 c/s transformer has a resonant frequency near 100 c/s or a multiple thereof, it will actually increase the noise level.

In some cases, where the transformer is standing on a foundation which itself is likely to radiate the vibrations transmitted to it, or which will transmit these vibrations to some other structure or body which can radiate noise, a reduction can be achieved by interposing anti-vibration mountings between tank and foundation.

The final remedy left is to enclose the transformer partially or completely. A typical steel enclosure is shown in Fig 4. Enclosures can be designed to give up

Fig 3.

The pattern of magnetostriction distribution over three laminations, two with relatively low watt loss and one with a higher watt loss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to 35 db attenuation, depending upon the material and construction used.

The Ferranti 'Backbone' core referred to earlier has been developed as a direct result of this research into transformer noise. It is shown in Fig 5, and incorporates four features: backbone, banding, balancing and mitreing.

The object of this design is to make a more efficient utilisation of cold-rolled grain-oriented steel and to improve the noise characteristics based on the considerations in this review, *i e* elimination of bolt holes, use of mitred corners, uniform pressure, prevention of cross-fluxing, and suspension at nodal points.

At points on the backbone, keyplates are welded on to the backbone to form a 'hanger' from which the leg laminations are suspended. Over the outside leg laminations, a steel stiffening plate is positioned which extends over the whole length of the leg, partly covering the top and bottom corners and centrally located by a locking plate. The stiffening plate also serves to carry some of the top and bottom coil supports and contributes to the rigidity of the structure when the complete transformer rests on its backbone.

Because the entire core is thus hung on the backbone of each leg, reasons of symmetry suggest that the magnetostrictive vibration would be at a minimum. This results in a reduction of the amount of noise transmitted directly from the core to the tank bottom.

The laminations are held in place by steel bands which encircle the legs and yokes and are insulated from the core by circumferential strips of pressboard.

The bands are positively located longitudinally by slotted strips which also serve as location points for the windings and relieve mechanical pressure on the band insulation at those points. Two insulated sections are included in the steel bands and screw adjustment is provided to adjust each band tension. The bands are

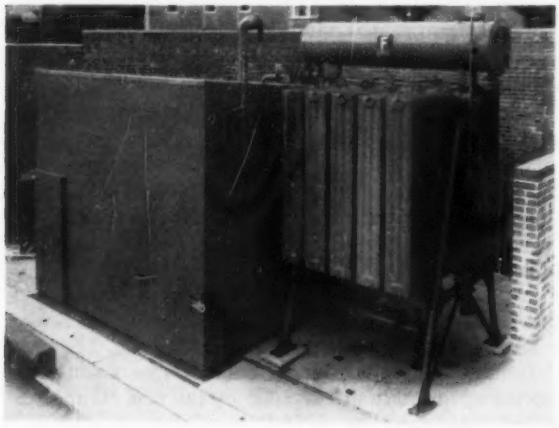


Fig 4.
Typical steel noise attenuation enclosure surrounding a 10MVA 33/11kV transformer

not used to pull the core tight, but the latter is compressed under hydraulic pressure to a pre-determined value and the bands are fitted and tightened with the core in this position. As the amount of core compression affects the noise level, correct tension is essential.

The insulation between the half-bands and between bands and core will withstand a routine 2 000 V, 50 c/s pressure test and impulse voltage up to 25 kV.

To relieve still further the mechanical pressure on the band insulation, there are insulated angle pieces (having rounded apices) fitted over the edges of each step.

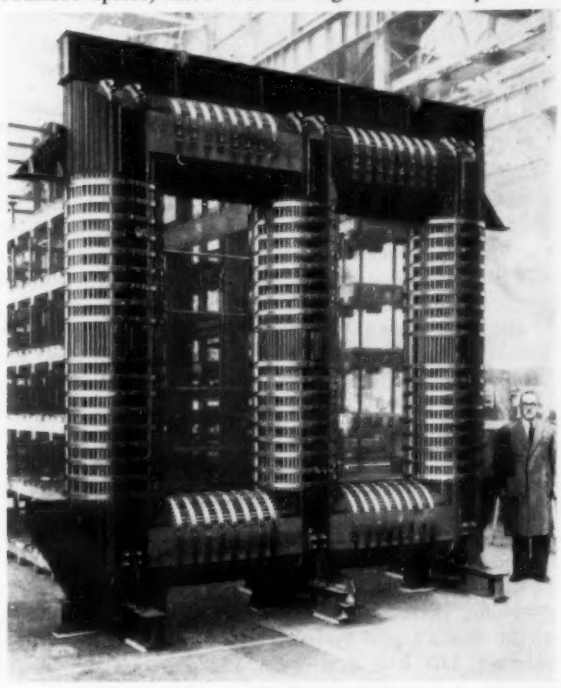


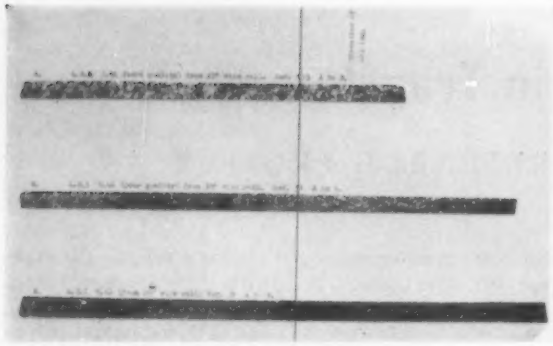
Fig 5.
60 MVA transformer core of 'Backbone' construction

The joints between leg and yoke laminations are mitred, with alternate joints off-set to provide the necessary overlap. The minimum off-set is 0·5 inch (12·7 mm), the actual value depending on the size of core and space required for the pins. These metal pins are insulated (or entirely of insulating material) and serve to suspend the bottom yoke laminations from the leg laminations. They are positioned in the area of over-lap and can be made small in view of the very low stresses produced in them. This is because bending moments and shear forces are produced by only 2 or 4 laminations acting alternately upwards and downwards across very short spans.

The leg and yoke sections are identical in shape, each step in the yoke being of the same area as the corresponding leg step. This minimises 'cross-fluxing' and reduces iron loss, magnetising VA and noise.

In large cores cooling ducts are provided parallel to the laminations to give the desired value of heat gradient. In very large cores where the width of the available steel is insufficient, the leg or yoke width is made up of two laminations of unequal width placed side by side and over-lapped every other layer. The narrower laminations are supported by pins.

Ferranti Ltd have supplied or are building a total of 11 031 MVA of power transformers designed for 220 kV working or over, and some 34 211 MVA of power transformers designed for 66 kV and over, including some of the largest transformers ever supplied to electricity undertakings in all parts of the world.



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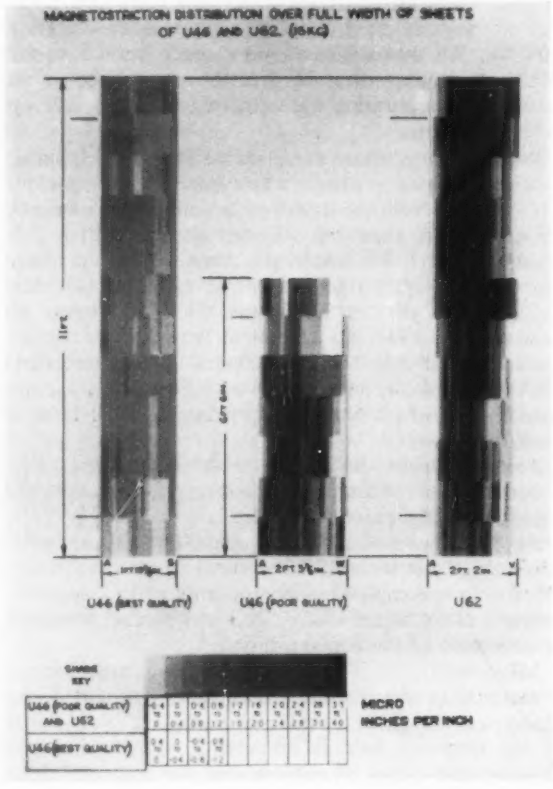
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The laminations are held in place by steel bands which encircle the legs and yokes and are insulated from the core by circumferential strips of pressboard.

The bands are positively located longitudinally by slotted strips which also serve as location points for the windings and relieve mechanical pressure on the band insulation at those points. Two insulated sections are included in the steel bands and screw adjustment is provided to adjust each band tension. The bands are

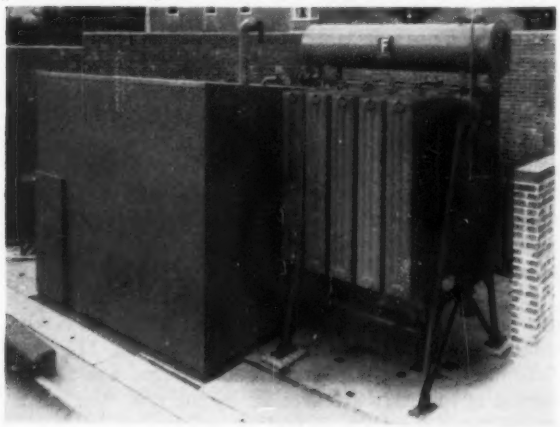


Fig 4.
Typical steel noise attenuation enclosure surrounding a 10MVA 33/11kV transformer

not used to pull the core tight, but the latter is compressed under hydraulic pressure to a pre-determined value and the bands are fitted and tightened with the core in this position. As the amount of core compression affects the noise level, correct tension is essential.

The insulation between the half-bands and between bands and core will withstand a routine 2 000 V, 50 c/s pressure test and impulse voltage up to 25 kV.

To relieve still further the mechanical pressure on the band insulation, there are insulated angle pieces (having rounded apices) fitted over the edges of each step.

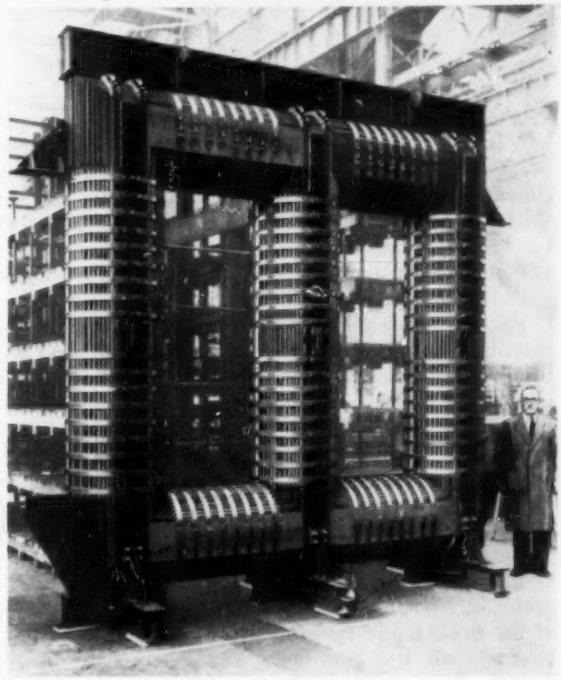


Fig 5.
60 MVA transformer core of 'Backbone' construction

The joints between leg and yoke laminations are mitred, with alternate joints off-set to provide the necessary overlap. The minimum off-set is 0·5 inch (12·7 mm), the actual value depending on the size of core and space required for the pins. These metal pins are insulated (or entirely of insulating material) and serve to suspend the bottom yoke laminations from the leg laminations. They are positioned in the area of over-lap and can be made small in view of the very low stresses produced in them. This is because bending moments and shear forces are produced by only 2 or 4 laminations acting alternately upwards and downwards across very short spans.

The leg and yoke sections are identical in shape, each step in the yoke being of the same area as the corresponding leg step. This minimises 'cross-fluxing' and reduces iron loss, magnetising VA and noise.

In large cores cooling ducts are provided parallel to the laminations to give the desired value of heat gradient. In very large cores where the width of the available steel is insufficient, the leg or yoke width is made up of two laminations of unequal width placed side by side and over-lapped every other layer. The narrower laminations are supported by pins.

Ferranti Ltd have supplied or are building a total of 11 031 MVA of power transformers designed for 220 kV working or over, and some 34 211 MVA of power transformers designed for 66 kV and over, including some of the largest transformers ever supplied to electricity undertakings in all parts of the world.

High Voltage Insulators in the Making

DOULTON INDUSTRIAL PORCELAINS LTD held an 'open day' at their Wilnecote factory, near Tamworth, Staffordshire, recently, when visitors—who were mainly electrical engineers—had an opportunity to see the processes and techniques used in the manufacture of all types of porcelain insulators. The chief purpose of the visit was to show a new type of post insulator for use with very high voltages.

The development of electrical engineering techniques towards very high voltages for power transmission has brought with it many problems, of which insulation is one of the greatest, and one in which porcelain plays a major role. With this thought in mind Doulton Industrial Porcelains Ltd, in association with MM. Merlin-Gorin of Grenoble, France, have developed an entirely new form of construction for high voltage post insulators.

The product of much research, the Doulton 'Multicone' post insulator has been designed to overcome the many problems associated with the increasingly high voltages of the world's grid systems. System voltages have now reached 380 kV, and even higher voltages—up to 700 kV—are contemplated.

At these voltages the design of suitable insulating pillars for equipment such as disconnecting switches becomes increasingly complex if conventional methods are used.

The normal support insulator for 275 kV already reaches 10 feet (3 m) in height and the space required for substations at these high voltages has been an embarrassment for supply engineers, not only for outdoor construction but especially for the indoor or protected stations which are now being specified for some coastal areas.

A Royal Doulton craftsman at work erecting a new insulator

The Doulton 'Multicone' insulator would seem to present a considerable advance in the manufacture of equipment capable of dealing with these problems.

In Europe, stations have used insulators constructed on similar lines which have been in service extensively and successfully for a number of years. The design of these insulators differs from those now being produced by Doultons in that they have a lower mechanical rating and embody plain sheds instead of antifog construction, but in principle are representative of this new development.

Outstanding Characteristics

The new insulator has many outstanding characteristics. The porcelain elements are in the form of cones fitting one inside the other and bonded by cement joints; there is therefore no internal creepage path which can be broken down.

The puncture path is through many layers of porcelain and the voltage required to break down this path is so high, compared with the external flashover value, that nothing approaching it can be maintained.

Difficulties have been experienced in obtaining low deflection figures at cantilever loadings with the normal pedestal post assembly. This is due to the fact that the main loading parts are metal at relatively small diameters.

For example, a 275 kV post of the conventional type to meet normal British practice requires 14 metal components in addition to the top and bottom fixing flanges. The equivalent post of 'Multicone' design uses only two. As a direct result, the deflection of the Doulton 'Multicone' post is less than one-third of the conventional post.

In many cylindrical designs of similar external appearance, considerable problems arise because a hollow tubular method of construction must be used. The great difficulties of sealing internal air spaces against the ingress of moisture are avoided by the new 'Multicone' design, since there are, in fact, no internal air spaces.

The reduction in the number of metal components means that the creepage length can be achieved with an assembly of considerably less height than that of the conventional pedestal design.

Another feature is that the stress grading ring of the 'Multicone' design is greatly reduced in diameter as compared with the orthodox pedestal post, which means that phase centres can be reduced while providing the same clearance, thereby reducing the occupation of substation space.

Corona Levels

Regarding corona levels, field plots using electrolytic tank techniques have established the optimum configuration of corona ring and pillar design, and subsequent full-scale tests have confirmed that satisfactory visible corona levels can be achieved with rings of smaller dimensions.

The flashover values obtained on test with standard 1/50 wave were appreciably higher than those of conventional designs. This is due to the uniform nature of the electrical field and is a particularly important factor in posts for very high voltages.

As there are practically no interruptions to the surface profile of the insulator from one end to the other, the maximum number of sheds can be provided. It has been possible to provide 1 inch (25·4 mm) per kV at even the highest voltages, while maintaining the minimum height appropriate to the impulse flashover level.

Standard manufacturing processes are used, and the component parts used in the 'Multicone' arrangement are comparatively small in size—a feature which offers many advantages, the principal one being that all porcelain parts can be made by the conventional 'jolley' method, which is still the most reliable way of producing a consistent and high performance porcelain article. In addition, all parts are suitable for normal tunnel kiln firing under highly controlled conditions with the quickest time cycle and a high degree of consistency and quality.

Standard testing methods can be used, because the shape of the porcelain parts is such that normal power frequency or high frequency routine tests can be carried out with confidence.

Technical data of the post insulators are given below. The performance figures quoted are the minima for the arrangements tested, and can be modified to suit specific service requirements.

TYPICAL 'MULTICONE' POST PERFORMANCE
(Upright, outdoor type)

	275 kV	380 kV
Visible corona (with 22 in (56 cm) diameter ring) (kV)	220	280
Dry flashover (kV)	661	762
Wet flashover (kV)	546	686
Impulse voltage withstand (kVp)	1 050	1 425
50 per cent impulse flashover	1 456	1 810
Total creepage (in)	300	400
(m)	7·6	10·2
Protected creepage (in)	150	200
(m)	3·8	5·1
Vertical working load (lb)	2 000	2 000
(kg)	907	907
Tensile breaking load (lb)	20 000	20 000
(kg)	9 070	9 070
Torsion working load (lb/ft)	1 200	1 200
(kg/m)	1 786	1 786
Cantilever working load (lb)	500	500
(kg)	227	227
Cantilever breaking load (lb)	2 000	2 000
(kg)	907	907
Deflection at working load (in)	$\frac{7}{32}$	$\frac{9}{32}$
(mm)	5·6	7·1
Vibration test load (lb)	500/1 250	500/1 250
(kg)	227/567	227/567
Overall height (in)	110·5	140·5
(m)	2·8	3·56

Finishing a section of a post insulator by the 'jolley' method

World's Largest Flexible Submarine Gas Pipeline

SUBMARINE cables for the transmission of electricity are being used all over the world. Now a new development employing the techniques of cable manufacture has been utilised to carry natural gas under the oceans and direct to the consumer.

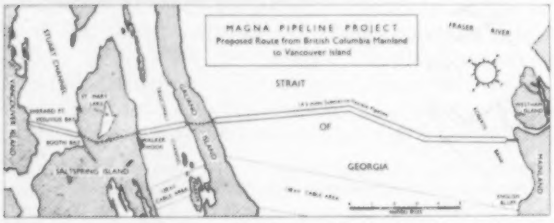
The new pipeline has the same appearance as an ordinary electric cable, the inner core being replaced by an inner plastic pipe for retaining gas or oil.

In face of strong competition a 7 million dollar contract from the Magna Pipeline Company Ltd of Vancouver, British Columbia, Canada, has been placed with British Insulated Callender's Cables Ltd to manufacture, install and commission 53 miles (85 km) of flexible submarine pipeline to transmit a supply of natural gas from the mainland of British Columbia to Vancouver Island. When the project is completed the installation will constitute the world's longest flexible submarine gas pipeline. It will bring to consumers on Vancouver Island all the economic advantages of natural gas that now exist on the gas grid of the U S A and Canada.

The flexible pipeline consists basically of an inner high-impact plastic pipe which is reinforced against internal pressure by helically-applied steel tapes which are protected against corrosion by an outer sheath.

The plastic pipe and the sheath of each length are free from joints. The main advantages of flexible pipelines are that their smooth internal surface offers a low resistance to fluid flow and does not tend to cause incrustation with paraffin wax when oil is conveyed. Moreover, they are supplied in lengths free from joints or welds and their associated protuberances, giving the further advantage of low hydraulic and pneumatic flow resistance values.

In recent tests that have been carried out on the high-impact plastic pipe in respect of stability and deterioration in contact with fluids, it has been found that the pipe is extremely inert and resistant to aliphatic and low aromatic content hydrocarbons. It has also been found that installation is quick and low in cost because long lengths are used and the laying equipment is extremely simple, the cable being carried in the hold of the laying ship and not reeled.



Proposed route of the gas pipeline, and (in broken lines) the area of the 133 kV power cable laid in 1956

The proposed pipeline is a development of the pipeline made for the wartime 'Operation Pluto' to which the companies now concerned with this new contract made a notable contribution. These pipelines carried petrol under the English Channel during the Normandy landings in 1944 and played a prominent part in the success of that operation. It will be remembered that 'Pluto' was laid across the Channel a few hours after the Allied landings and the petrol was being pumped through it a few days later. It will also be remembered that it was the flexibility of these pipelines and the ease with which they were laid that made them such a success.

High-Voltage Cable Techniques

The flexible pipeline for the Magna Company is also a development of the supervoltage submarine power cable pioneered by the B I C C Group; its design follows closely the 'Pluto' principles and normal high-voltage cable-making practice. Existing cable-making plant will be used in its manufacture, and it will be laid by equipment similar to that which is used for deep-sea submarine telegraph and telephone cables and, in more recent years, electric power cables.

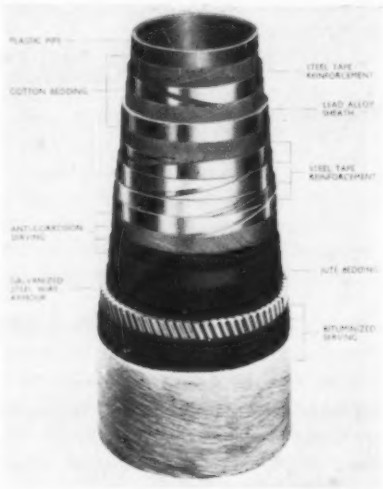
The pipeline is designed primarily for the transmission of gas or fluids under long stretches of water where its flexibility and long continuous lengths facilitate its installation. Flexibility is not generally a matter of importance for the installation of solid land pipes and the future of this type of pipeline should prove of tremendous value in the field of underwater transmission.

The system now ordered by the Magna Company consists of two flexible pipes laid adjacently, which are required to pass a series of most stringent tests including, for example, the ability to transmit approximately 50 million cubic feet (1 416 000 m³) of natural gas in 24 hours. This is equivalent to 750 000 h p or 560 MW, which is slightly greater than the MW capacity of the Battersea power station. Each pipe will have an external diameter of 7·5 in (19 cm) and will operate at a gas pressure of 1 500 lb/in² (105 kg/cm²). Gas will travel through the pipeline at approximately 40 mile/h (64 km/h). The maximum depth of laying will be about 810 feet (246 m) and the pipe will not be trenched into the sea. The pipeline will be laid across the Georgia Strait which separates Vancouver Island from the mainland and the pipes will be laid in continuous lengths across the Strait, passing through two intermediate islands, both of which will be crossed with conventional steel pipes.

The manufacture of the flexible pipe will be undertaken by British Insulated Callender's (Submarine Cables) Ltd at Trafford Park, Manchester, and the installation will be by British Insulated Callender's Construction Company Ltd, both members of the B I C C Group. The consulting engineers are International Power and Engineering Consultants of Vancouver, B C, whose president, Dr T. Ingledow, was responsible for the inception and engineering of the Vancouver submarine cable scheme.

It is planned that the laying operation of the Magna pipeline should be carried out in 1963.

It will be recalled that in 1956 B I C C laid 93 miles (150 km) of high-voltage submarine power cables along a route almost parallel to that now proposed for the pipeline.*



A section of the flexible submarine gas pipe showing details of its construction

These cables, commissioned in the presence of the Premier of the Province of British Columbia in September 1956, together with 42 miles (68 km) of similar cables installed in 1958, have given continuous service.

*THE BEAMA JOURNAL, **63,** No 4, p 154

The Commonwealth 'Round-the-World' Telephone Cable Project

In his paper* at the British Electrical Conference in 1958, organised by The BEAMA in conjunction with the Brussels World Exhibition, Sir Gordon Radley, the then Director-General of the British Post Office, said: 'In no branch of applied science, with the possible exception of the application of nuclear physics, has progress been more rapid during the past few decades'.

He was referring to telephone communication across the world, with particular reference to the then newly-completed Trans-Atlantic telephone cable.

Shortly after that Conference came the news of the decision to proceed with the vast project for a Commonwealth telephone cable system that would literally encircle the world.†

It has recently been announced that plans for the Pacific Ocean cable (code name Compac) are now well in hand, and that this further link is due for completion in 1964. Orders worth £10 million and £9 million respectively have been placed with Submarine Cables Ltd (jointly owned by Associated Electrical Industries Ltd and British Insulated Callender's Cables Ltd) and Standard Telephones and Cables Ltd for the supply of cables, submerged telephone repeaters and submerged equalisers for this project. Submarine Cables Ltd are supplying about two-thirds of the cable and one-quarter of the submerged repeaters required, and Standard Telephones and Cables Ltd will supply the remaining one-third of the cable, three-quarters of the repeaters and all the equalisers required for the contract.

A Commonwealth Partnership

The orders have been placed by Cable and Wireless Ltd on their own behalf and also on behalf of their partners: the Overseas Telecommunications Commission (Australia), the Canadian Overseas Telecommunication Corporation, and the New Zealand Post Office. The Compac project as a whole is under the general control of the Pacific Cable Management Committee composed of representatives from the four Commonwealth partners (Australia, Canada, New Zealand and the United Kingdom), with Mr T. A. Housley, General Manager of the Overseas Telecommunications Commission (Australia) as Convenor. The engineering aspects of the submarine sections are the responsibility of a special engineering development group headed by Mr R. J. Halsey, Director of Research in the U K Post Office Engineering Department and a director of Cable and Wireless Ltd.

The Compac Trans-Pacific cable will be the second link in the proposed telephone cable link round the world. The first link, called Cantat, will go into service this year and will join the United Kingdom to Canada via Newfoundland. The Cantat system will then be linked across Canada with Vancouver, the Canadian terminal of the Compac system.

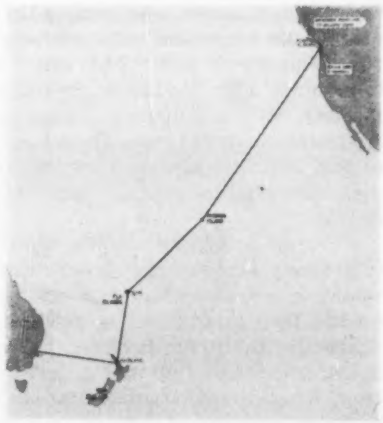
Standard Telephones and Cables Ltd are providing all the repeaters and equalisers for the Trans-Atlantic section of Cantat, as well as the cable and repeaters which are being laid across Newfoundland. Submarine Cables Ltd have the contract for 2 200 nautical miles (4 076 km) of submarine cable for the main Cantat crossing and for the submarine cable and submerged repeaters in the shallow water extension between Newfoundland and the mainland of Canada.

Like Cantat, the new Pacific cable system will have bandwidths equivalent to 60 two-way speech circuits spaced 4 kc/s apart, or their equivalent using other types of frequency multiplex equipment (*e g* 80 circuits using 3 kc/s channel equipment).

Follows 1902 Cable Route

The Compac cable route will, to a great extent, follow the 1902 'all-red' telegraph cable route. The approximate route is between Sydney (Australia) and Vancouver (Canada), with landing points at Auckland (New Zealand), Suva (Fiji Islands), and Fanning Island.

Some idea of the magnitude of the Compac project, the total cost of which has been announced as £26 million, may be seen from the following table of approximate data.



The route of the Compac cable across the Pacific Ocean from Australia to Canada

Section of Route	Cable Length Nautical Miles	Cable Length km	Number of Submerged Repeaters	Maximum Depth of Water Fathoms	Maximum Depth of Water m
Sydney-Auckland	1 242	2 300	49	2 600	4 755
Auckland-Fiji	1 214	2 230	49	2 500	4 572
Fiji-Fanning Is.	2 002	3 720	76	3 000	5 486
Fanning Is.-Vancouver	3 544	6 600	140	3 400	6 218
Totals	8 002	14 850	314		

* THE BEAMA JOURNAL, **65**, No 2, p 51

† THE BEAMA JOURNAL, **65**, No 4, p 140

As much as possible of the raw material required will be obtained from Australia and Canada.

The Compac cables will be similar to the Cantat cables now being manufactured. Only 3 per cent of all the cables required will be in shallow water; hence only some 270 miles (435 km) of cable will need to be armoured for protection against possible damage by ships' anchors or fishing trawls. Almost all the cable

Cut-away section of the unarmoured (lightweight) cable for the deep-sea route

will be in deep sea and will be of the unarmoured (or so-called 'lightweight') form described by Sir Gordon Radley in his Brussels paper. This type of cable was proposed by the British Post Office and developed in collaboration with the manufacturers concerned.

Details of the Lightweight Cable

The mechanical strength required for laying this cable is provided, not by conventional outer armouring, but by a central high-tensile steel wire strand. This is surrounded by a copper tube forming the central conductor which is then insulated with polythene to a diameter of approximately 1 inch (2·54 cm). Aluminium tapes, forming the outer conductor, are laid over the polythene together with a polythene binder tape and a single aluminium screening tape. The whole is given a lapping of anti-corrosion tape followed by an outer sheathing of polythene to an overall diameter of about 1·25 inches (3·18 cm).

An armoured cable of the same overall diameter (but having a considerably lower electrical performance) would, in air, weigh half as much again, and in water no less than three times as much as the unarmoured lightweight cable. Furthermore, the unarmoured cable, unlike conventional armoured cable, does not twist or kink. Thus the unarmoured cable greatly eases the problems of laying, particularly in deep water.

The inner copper conductor and the outer aluminium-tape conductor together comprise a communication cable of 'coaxial' form to carry the high-frequency currents (ranging from 60 to 608 kc/s) corresponding to 80 simultaneous both-way conversations. The inner conductor also carries d c which passes along the cable and through each repeater in succession, returning via the sea, to energise the valves in the repeaters. The voltage required at each end of the cable to maintain this current will be about 5 000 V for the longest section.

The submerged repeaters will be inserted in the cable at intervals of about 26 miles (42 km). Each repeater consists of an amplifier, which amplifies all the conversations simultaneously in both directions, together with filters, equalisers and supervisory apparatus. Over 300 electrical components are assembled in brass or copper containers to form in all about eight units which are mounted in a framework of Perspex bars and enclosed in a hermetically-sealed thin brass tube. The latter is then inserted in a thick steel tube housing capable of withstanding sea-bottom pressures up to 5 or 6 tons/in^2 (7·9 or 9·5 kg/mm^2).

Service Life of 20 Years

The two ends of lightweight cable which have to enter a repeater are armoured for a few fathoms on each side of the repeater so that the tension in the central strand may be transferred through the various layers of tapes and polythene to the armour wires. These armour wires (or the armour wires of the conventional armoured cable used in shallow water) are anchored in special clamps attached to each end of the housing. Carefully machined bulkheads are brazed into each end of the housing proper; thus the brass inner tube does not have to withstand sea pressure. The outer conductor tapes are terminated on the bulkheads while the inner conductors pass through a special gland which forms an integral part of each bulkhead. These glands are also capable of withstanding the full sea pressure.

The completed repeater is about 10 feet (305 cm) long, 10½ inches (26·7 cm) in diameter and weighs half a ton (508 kg). Extreme care is taken at all stages of production with the expectation that it will give service, undisturbed on the ocean bed, for at least 20 years.

Manufacture of the equipment for the Compac project will follow immediately on the Cantat system. The decision to place orders for Compac before Cantat has been laid shows great confidence in this form of communication and praiseworthy enterprise on the part of the Commonwealth partners concerned.

Wiring a submerged repeater amplifier unit, which consists of two separate amplifiers coupled in such a way that if one fails, the other can carry on indefinitely with a negligible loss of overall performance

Notes

Increasing the Power of Britain's Supergrid
With a view to reducing the number of high-voltage transmission lines and at the same time meeting the country's rapidly increasing demand for electrical power, the Central Electricity Generating Board is to adopt a 400 kV system.

The majority of existing 275 kV supergrid lines were originally designed with an eye to future conversion to 380 kV, and where increased transmission capacity is necessary they will be reinsulated and used for the new high voltage. The power-carrying capacity of each double-circuit line will thereby be raised from 1 200 MW to 2 000 MW.

For new main trunk lines, the Board plans to introduce a new design of tower, carrying four conductors per phase as compared with two per phase on the 275 kV lines. The new towers will of necessity be about 20 feet (6·1 m) taller than existing 275 kV towers, but this disadvantage will be outweighed by a further increase in power-carrying capacity to 3 000 MW.

Studies have shown that, for the transmission distances in Britain, there is no great economic advantage to be gained from the use of the higher voltage. However, there is some technical advantage and there is a very substantial advantage to amenity because, with a higher power carrying capacity, fewer new lines will be needed.

Technology is judged to be far enough advanced for orders for equipment to be placed in the near future without waiting for operating experience with the 380 kV experimental circuit between Monk Fryston and High Marnham, which will come into service in 1962. The first 400 kV line should then come into commercial use in 1965.

From then on the new voltage will be introduced gradually to meet growing demands on the system. Modifications to existing lines to suit 400 kV will include the substitution of a different type of insulator on the existing towers, together with the provision of new transformers and switchgear at terminal substations. The changeover will require to be carefully worked out in order to maintain security of supplies to consumers and to cope with the growing demand while taking lines out of service successively for conversion.

Although the technical and economic advantages of the higher voltage in England and Wales are not so great as in many other countries where much longer transmission distances are involved, the adoption of 400 kV will bring this country to the fore in the field of high-voltage electrical power transmission. It is the highest voltage in commercial use outside the U S S R. It will also furnish British manufacturers with valuable experience which will be of great value to them in meeting the requirements of overseas countries.

London's Buses to be Computer-Controlled?
London will be the first city in the world to operate its buses according to timetables compiled by an electronic computer, if the present rate of progress on automatic time table compilation is maintained. This would then bring about the rapid production of schedules reflecting the changing requirements of passengers.

Members of London Transport's Electronic Data Processing Unit and E M I Electronics Ltd have been jointly investigating the problem for several months. They have now succeeded in compiling and printing in 30 seconds on an E M I D E C 1 100 computer a timetable for the simplest type of bus route which would take a schedule compiler at least an hour to produce manually in rough outline.

In the U S A, computers have been used merely to collate passenger loading information and to print out the final documents after the timetable has been compiled mainly by hand. Nothing is known of developments anywhere in the world similar to those now being undertaken by London Transport.

It is emphasised that much work remains to be done before more complex operating timetables can be compiled by computer, but London Transport is very hopeful that the E M I D E C will make it possible to produce schedules and related statistical information, vehicle time cards and inspectors' time books much more quickly and economically than by manual methods.

In order to gain an insight into the problem, the simplest type of bus route—from A to B, without any intermediate turning points or branches—was taken as a basis, and the logical rules underlying the compilation of a timetable for such a route were determined. From these rules, a detailed computer programme was built up.

This programme needs to be written only once, since it will accept variations in specifications for different routes. The computer can then compile the complete timetable for a particular route in 10 seconds and immediately print out the information in as many different forms as are needed.

There is an even greater saving in time when producing the subsidiary documents than there is in printing the time schedule.

The next problem is to define the logic and write the computer programmes for the more complex types of timetable, comprising several intermediate turning points, two or more garage allocations, and inter-working requirements where several routes follow the same path over parts of the journeys.

This will be more difficult, but the experience gained so far with E M I D E C will prove valuable by pointing the way to solutions of the more complex problems.

New Zealand's First Broadband Microwave Telephone System in Service
Wellington, the capital of New Zealand, and Auckland, the country's largest city, are now linked by a 262 mile (422 km) microwave multi-circuit telephone system supplied by Standard Telephones and Cables Ltd. The system lends itself, with certain additions, to the carrying of television programmes, using the existing equipment and buildings.

The link at present has one two-way radio channel which is capable of carrying 600 simultaneous telephone calls. There is also an identical 'stand-by' radio channel to which all telephone traffic can be switched automatically in the event of excessive noise or severe fading on the 'working' channel.

The radio terminals for the new 4 000 Mc/s radio link are at Hamilton and Palmerston North: these are linked by cables to Auckland and Wellington respectively. There is also a spur connection between Urenui, on the main link, and New Plymouth, on the west coast.

Between Hamilton and Palmerston North eight repeater stations amplify the broadband block of 600 telephone channels. The incidence of earthquake shocks and high winds called for special care in the construction of the 80 feet (24 m) high masts at these stations. This type of communication system uses a transmitter power of only 5 W, concentrated into a very narrow beam. Consequently, the alignment of the aerials must remain correct in all circumstances to maintain the quality of the link.

The automatic supervisory equipment for the microwave link uses a VHF radio system also supplied by Standard Telephones and Cables Ltd. This supervisory channel enables faults at repeaters to be reported and identified at the terminal control stations; it also allows the control stations to interrogate each repeater for checking its operational condition.

'No-break' power supply equipment has been provided so that, in the event of failure of the regular supply, the equipment can be switched over immediately to the stand-by plant, ensuring continuity of service.

Automatic Welding of Piston Heads
An interesting example of the use of automatic arc welding equipment has been put into practice at the Sheffield factory of Lockwood and Carlisle Ltd, marine engine piston ring specialists.

The repeater station at Urenui, North Island, New Zealand. The paraboloid aerials are 10 feet (3 m) in diameter. Aerials for the VHF supervisory link are mounted at the top of the mast

The application concerns the renovation of complete steel piston heads of marine engines after long use. When these heads arrive at the factory, the wear on the grooves is found to be extremely severe.

These grooves are first cleaned out in order to take a range of widths of wearing rings. (The rings are in halves, with overlapping 'L' joints.) The rings are then welded in place. For this purpose, the Autopak arc-welding equipment made by Rockweld Ltd is employed. Finally, the grooves are machined to the manufacturers' standard width and then ground. The result, in most cases, is virtually a new piston.

Lockwood & Carlisle Ltd carry out this work as a service to ship owners. Pistons from 22 inches (560 mm) diameter up to those of the largest marine diesel engines in use are handled.

The Autopak is used in preference to hand welding because it gives a continuous weld. It is also of course much quicker. The saving in time and the overall economy afforded by the Autopak have been utilised to perfect the finish, and this has enabled the company to give clients a good service at an economical price.

One operator only is required to control the Autopak in this application, and the current required is usually of the order of 390 A.

In the Autopak, Rockweld concentrated on devising a system of control which would afford improved sensitivity as compared with other known methods, and on producing a machine primarily intended for the fabrication shop with the emphasis on versatility, robustness and simplicity of maintenance. In fact, one of the factors which influenced Lockwood & Carlisle to purchase the Autopak was its simplicity.

Sea Water Distillation Plant for South-West Africa

G. & J. Weir Ltd, of Glasgow, have recently received an order from the South-West African Administration, Water Affairs Branch, for a Weir 'Multiflash' sea water distillation plant.

The order, obtained through their South African representatives, Fraser & Chalmers (S A) (Pty) Ltd, is for a plant similar to that which they have recently completed in Guernsey, Channel Islands,* and will produce 120 120 imperial gallons (545 545 litres) of pure fresh water daily from the sea.

Luderitz is a small seaport and railway terminal in South-West Africa serving the Namaqualand alluvial diamond mining area, and a crayfish canning industry is carried on which uses some 20 per cent of the water at present available. The remainder is used for domestic purposes. Water from existing sources is very expensive, and it is expected that the 'Weirwater' produced by the new plant will cost well under half the current price. This will lead to an increased demand, and the new plant is designed to cover the expected requirements for the next eight or nine years.

The installation will operate in conjunction with an existing electricity generating station, and will use bled steam from the main turbines as the heating medium.

Nickel and Chromium Recovery in the Electroplating Industry

The results of a survey by the Department of Scientific and Industrial Research, in co-operation with the British Non-Ferrous Metals Research Association and the electroplating industry, were published recently under the title *A Survey of Nickel and Chromium Recovery in the Electroplating Industry*. The wastage of nickel and chromium salts in the electroplating industry is not only substantial but often causes a pollution problem to both the electroplater and the drainage authority. Promising lines of attack for the elimination of waste and the reduction of pollution are discussed in the survey, copies of which can be obtained free from the Library, Department of Scientific and Industrial Research, 5-11 Regent Street, London, S W 1.

Nickel and chromium salts are largely wasted by 'drag-out'—the carrying away of the solution by plated articles as they leave the plating bath, though spray formation is often a cause as well. Out of an estimated total weight of 2 870 tons of nickel used by the plating industry in 1958, about 290 tons represented the metal content of the nickel sulphate and chloride used. These chemicals increase the total material cost by about 13 per cent.

The use of a simple static rinse tank has been found to eliminate three-quarters of the cost of these added salts. Installation of such a tank in a manually-operated plant is usually inexpensive, and the outlay may be recovered within one year. Reduction in water consumption by use of counterflow rinses is also recommended.

The author, E. P. Harris, A R S M, B SC, F I M, further concludes that there is great potential value in the ion-exchange process for the purification and re-use of effluent solutions. At present this process is handicapped by the initial cost of equipment and lack of operating experience. It is, however, a promising alternative to present effluent treatment by chemical means, which reduces impurities to a valueless sludge.

U K has World's Largest Automatic Telex Exchange

The recent opening of the new automatic telex exchange in London—known as the Fleet Exchange—gives the United Kingdom the largest automatic telex exchange in the world. Its present capacity is 5 000 subscribers' lines, but it has been designed for an ultimate capacity of 15 000 lines.

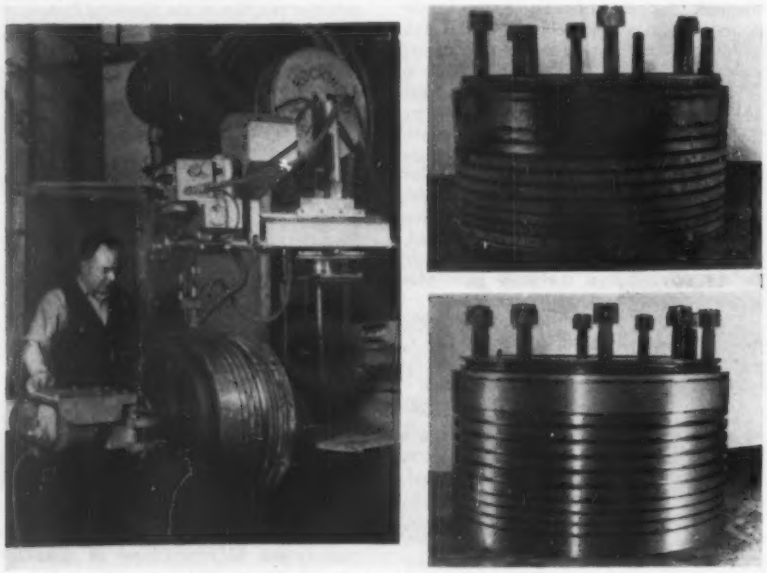
The inland telex service is now completely automatic, and all telex calls in the U K can be completed by dialling. This has involved the installation of 20 exchanges.

The exchanges use electro-mechanical switching principles similar to those in the telephone exchanges. The telex system is however completely separate from the telephone system, although full use is made of the telephone cable network for routing telex circuits. Multi-channel voice frequency telegraph systems are used for the inter-exchange trunk circuits and for long subscribers' lines; these systems enable up to 24 telegraph circuits to be provided on one telephone circuit.

New English Electric Company in Portugal

The English Electric Company Ltd has established a local company in Portugal which will trade under the name of English Eléctrica de Portugal, Limitada. The company offices are at Rua Cascais, 47 (Alcantara), Lisbon.

The formation of English Eléctrica de Portugal has been welcomed by business interests in the country as a further sign of closer co-operation between English and Portuguese industry and commerce. The new company also ensures the continuity of English Electric agency arrangments in this territory, which have been firmly established since pre-war days and



(Left) *Welding the piston heads on the Autopak welder.* (Top right) *A piston head before renovation.* (Bottom right) *A piston head after treatment*

* THE BEAMA JOURNAL, **65**, No 4, p 157

are regarded as of major importance in maintaining a high level of exports from Britain to Portugal.

The manager of the new company is Mr R. I. Lewis, who has been the company's technical representative in Lisbon for some years and, together with Mr M. A. Nogueira, assistant manager of the company, will be directly responsible for the day-to-day business of the company.

Control Gear for 'Climbing' Cranes

The 32-ton three-motor 'climbing' cranes which are playing a spectacular part in the construction of the new road bridge across the Firth of Forth, in Scotland—the world's fourth longest suspension bridge—have electrical control gear manufactured by Allen West & Co Ltd, of Brighton, Sussex, to the order of John M. Henderson & Co Ltd, of Aberdeen.

The cranes are for the erection of the steelwork of the bridge's two main towers. As each tower rises on massive concrete foundations, the climbing structure built round the tower is raised progressively by a hydraulic jacking system until in the final stages the crane will be some 500 feet (152 m) above the river level.

At such heights, gales and heavy mist are serious hazards, and the electrical equipment has been designed to provide safeguards in these abnormal conditions.

Control gear for the hoisting motion is of contactor type with master drum controller, the contactor panel being provided with a strip heater. A 60 h p motor gives the crane a hoisting speed of 17 feet (5·2 m) per minute, with resistors continuously rated throughout for slow manoeuvring necessary for the accurate positioning of the steelwork. The slewing motor develops 7·5 h p, and has overload relays specially arranged to give protection against gale force winds. The derricking motion is driven from a 30 h p motor and control equipment arranged for plain rotor resistance control.

Refrigerators Travel Across Europe

Four railway wagons carrying 120 Electrolux refrigerators were one of the first consignments to be sent by British Railways across an overland rail route to Teheran, Persia. They left Leagrave Station, close to the Electrolux works at Luton in Bedfordshire and began their journey by way of the Harwich-Zeebrugge train ferry. The journey continued across Europe to Poland, and at Brest-Litovsk, about 100 miles (161 km) east of Warsaw, the refrigerators were transferred into Russian broad-gauge rolling stock before going on by rail through Russia and on across the Caucasus into Persia.

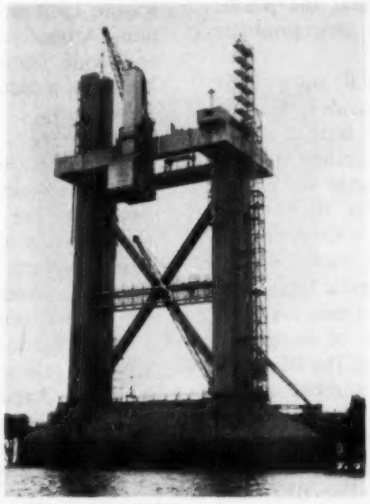
The consignment comprised 100 model L50 and 20 model L27 kerosene-operated refrigerators, and to ensure damage-free transit Electrolux devised special packaging. Each refrigerator was mounted on four rubber buffers; all vertical corners and the tops of the cabinets were protected by fabricated corrugated pad fittings and the front corner-pads were contoured to fit over the edges of the outer door panels. Too much pressure at any one point could cause indentation. Each refrigerator was wrapped in waxproofed paper—the wax acting as a lubricant in case of friction during transit, which could mark the high gloss enamel finish on the cabinet.

The packing cases were constructed of plywood with panelled battening, with girth battens and two vertical battens on each side of the lower half of each case to obviate damage during trucking.

Movable Substations for Mining in India

To supply stand-by power for pumping an opencast lignite mine near Madras, the English Electric Co Ltd have equipped two movable substations for the Neyveli Lignite Corporation (Private) Ltd, Madras. In the event of breakdown in the normal supply, these substations start automatically and supply power on a ring main system to submersible pumps which keep the mine workings dry.

Each substation houses three diesel-alternator sets and associated switchgear. The controls of each set are self-contained so that the substations can be moved completely as the face of the mine advances.



One of the bridge towers rising above the Firth of Forth, with a rear view of the 'Climbing Crane' at work

The six diesel engines, each mounted on an underbed, are of the 12 CSV exhaust turbo-charged type with charge air cooling. Each engine, having a site rating of 1 498 b h p when running at 750 rev/min, is directly coupled to a 1 037 kW alternator which generates at 11 kV, 3-phase, 50 c/s.

The six 6-panel switchboards each consist of one exciter control panel, one relay panel for automatic starting, one alternating incomer, one transformer incomer and two outgoing feeders. The supply is taken by 3-core 11 kV flexible cables made up from standard lengths with plug and socket connectors for lengthening or shortening as required.

Each diesel-alternator/switchgear set is complete with its own 110 V battery for control, solenoids and emergency lighting, and a 24 V battery for the 3 h p motor-driven lubricating oil priming pump.

If a failure occurs in the normal supply from the transformers, the diesel-alternator sets are started automatically. When they are running at the correct speed and voltage they trip out the transformer breaker and close the alternator breaker. These two breakers are electrically interlocked to prevent parallel operation. Restoration to the normal supply is carried out manually.

Harwell Radiation Protection Course

The fourth Advanced Course in 'The Principles of Radiation Protection' will be held in the Harwell Reactor School from April 19 to July 18, 1961.

The course, which comprises lectures, practical work, demonstrations and visits, is intended for graduates or persons of graduate standard either entering or already working in the field of radiological health and safety. The course will cover a wide field of fundamental background knowledge and will deal with principles rather than with particular techniques. A high academic standard is set, but since few academic courses cover all the necessary subjects, the course of lectures will begin with first principles, and will not require previous specialised knowledge.

Some of the lectures will be given by the staff of the school, but the majority will be delivered by experts from Harwell and other U K A E A establishments. It is also hoped, as on previous courses, to have lectures from experts from the Medical Research Council, the Agricultural Research Council, the Central Electricity Generating Board, the Institute of Cancer Research, the Radiological Protection Service and Ministry of Housing and Local Government.

The three courses held so far have proved to be very popular. The majority of students attending these courses have come from the U K A E A, with a small number from other organisations in the United Kingdom and from countries in Europe and Asia.

The theoretical part of the course consists of about 110 lectures under three main headings: Basic scientific principles (about 48 lectures); Principles of Radiation Protection (about 52 lectures); General topics (about 10 lectures).

Practical work will cover between 15 and 20 experiments, including some designed to illustrate basic principles and others intended to illustrate the principles of protection.

The programme of visits will include installations at Harwell and at some of the other establishments of the Research Group, and there will also be a tour of some of the U K A E A factories to acquaint students with the problems in health physics and safety in the main types of plants and installations of the atomic energy industry. It is also hoped, as on previous courses, to visit units of the Institute of Cancer Research and the Radiological Protection Service.

The fee for the course is £250, exclusive of accommodation, and application forms and further details can be obtained from The Manager, The Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire.

British Domestic Appliances at the Cologne Fair

THIS year the British electrical domestic appliance industry will be exhibiting at the International Household Goods and Hardware Fair in Cologne the largest display of British electrical equipment for the home yet staged in Europe. The Cologne Spring Fair—held this year from February 24 to 27—is one of the most important events of its kind in Europe. Last year it attracted over 1 600 exhibitors from 18 countries, and was visited by between 50 000 and 60 000 buyers from 60 countries.

The collective British exhibit, which is organised by the British Electrical and Allied Manufacturers' Association in conjunction with the U K Board of Trade, will demonstrate to international buyers that the British domestic appliance industry has much to offer in quality, design and wide range of products. With many new designs on show, British manufacturers are looking to the European market with confidence that the prices, styling, efficiency and general appeal of their products will find favour with overseas buyers.

This year nine British exhibitors will show their products on three adjacent large island stands in Hall II, near the main entrance and information bureau of the Fair. The three stands will be linked by a unified and distinctive décor, against which the large range of British domestic appliances will be shown. The BEAMA is issuing an illustrated descriptive booklet in German and English dealing with the exhibits, and there will be numerous articles on the British domestic appliance industry in the German newspapers and trade journals.

The whole project is one of a series of important events marking the Golden Jubilee Year of The BEAMA —the fiftieth anniversary of the establishment of the Association. It is against this background of 50 years of technical development and manufacturing experience that the British exhibits will make a strong appeal.

Mr Stanley F. Steward, Director of The BEAMA, in a statement which he made recently, said:

> 'We are determined to make this collective exhibit at Cologne one of the spearheads of our continuing drive to do more business in the European market. It is a sign of our confidence in the long-term prospects for British domestic electrical appliances, and we have urged the Government to help us in our efforts by creating the necessary foundation of stability in credit controls at home, as this factor is important in keeping down unit costs of production'.

The following firms are participating in the collective British exhibit:

Berry's Electric Magicoal Ltd
Corfield-Sigg Ltd
Dimplex Ltd
Electrical Division of Radiation Ltd
The English Electric Co Ltd
The General Electric Co Ltd
Heatrae Ltd
Simplex Electric Co Ltd
Thorn Electrical Industries Ltd

These nine firms cover between them practically the entire field of electric domestic appliances. Here is a forecast, written prior to the opening of the Fair, of the leading products which each firm expects to show and for which they have established a widely-known and well-deserved reputation.

Electric Fires

The Magicoal electric fire shown by Berry's Electric Magicoal Ltd reproduces electrically the warmth, the glow and movement and the appeal of a coal or log-fire. It was one of the most eye-catching exhibits at the Fair last year and proved of great interest to overseas buyers. The fire has many advantages: it needs no laying or clearing; it burns exactly when and for as long as it is needed without any attention, and it makes no dirt or soot to spoil or damage expensive furnishings or decorations. Attractive, efficient, and convenient, its advantages and wide choice of designs should again make the Magicoal a focus of interest.

Kitchen-ware

Kitchen-ware with its streamlined design and wide range of colours, manufactured in aluminium, will be a special feature of the exhibit by Corfield Sigg Ltd. The insides of all stewpans, saucepans, frypans and chip pans have been rounded to eliminate awkward crevices and corners and to facilitate easier cleaning. Pan lids are also smooth and rounded on the insides.

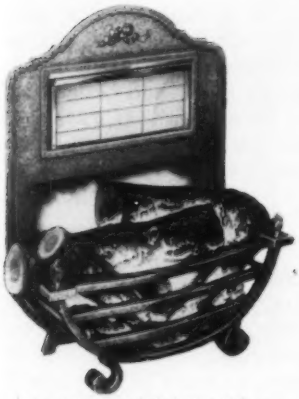
The new tricorn-shaped knobs are easy to hold and ensure a safe grip, even with soapy or greasy fingers. Saucepan handles are insulated with heat-resistant plastic and are reinforced with steel throughout their length for extra strength and stability.

Special 'easy-pour' rims are a feature of this kitchen hardware; they enable the contents to be poured with great accuracy and speed from whatever angle the pan is held so that no spilling occurs.

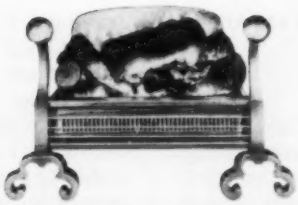
A new egg poacher assembly and porringer unit offers two utensils for the price of one, with interchangeable attachments. The egg poacher assembly has a four-egg tray and an interchangeable lid which fits either the tray or the 7 inch (17·8 cm) family-size Crown Merton frypan.

The new dual-purpose porringer unit consists of 3 and 4 pint (1·7 and 2·3 litre) tops and lids which have been designed to fit the standard Crown Merton 6 inch (15·2 cm) stewpan. By the addition of the top and lid the stewpan can be transformed into a porringer.

One new and novel feature in this exhibit is a jug that was designed especially for the use of the blind. It had been found that blind people were liable to burn themselves with some appliances normally in use, so this new model was designed with the heat-resistant plastic handle set well away from the body of the jug so that the hand would not touch any hot metal, and the 'easy-pour' rim enables the jug to be held at any angle for pouring.

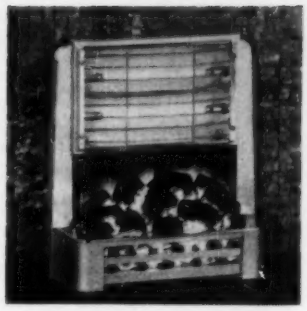


The Magicoal 2 kW Alderberry fire

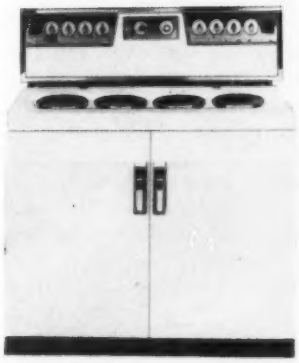


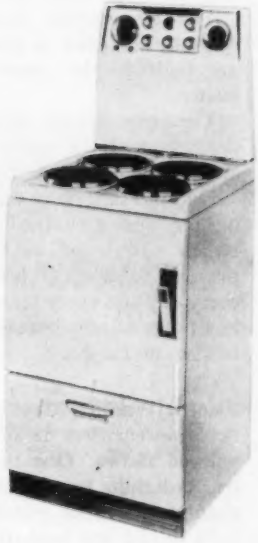
The Magicoal 1·5 kW Berrylog A21/0 fire

The Magicoal Berrylog A16 has no heating element and is used for its decorative effect in situations where 'unseen' warmth is provided by central heating



The Magicoal 2 kW Charmberry fire





(Left) *The Creda Constellation cooker with two ovens*
(Centre) *The Creda Capri 1 kW panel heater—an effective source of background heat*
(Right) *The Creda Mercury Super Four—an outstanding cooker offering rotisserie cooking*

(Left) *The new Tricity Diner-Cold refrigerator is housed in a polished sapele mahogany cabinet*
(Centre) *The Tricity Kitchencold 4·5 cu ft (127 litre) capacity refrigerator is identical internally with the Diner-Cold*
(Right) *A typical kitchen layout with the Tricity built-in cooker*

All these utensils are supplied with handles and knobs in a choice of red, yellow or blue colours.

Infra Red Heaters

Prominent in the display of electric heating equipment by Dimplex Ltd will be a range of infra-red heating appliances for domestic and commercial use, an enlarged range of permanently oil-filled electric towel rails, and a wide range of oil-filled radiators.

A wall-mounted infra-red heater with a built-in double pole cord-operated switch is ideal for bathrooms and kitchens because the totally enclosed element and wiring make it steam-proof. It is available in a range of colours and has a loading of 750 W.

Portable infra-red fires, all with totally enclosed elements and with loadings of 750 and 1 500 W, provide immediate beamed warmth whenever it is required. The reflectors on these fires can be adjusted even when the fire is switched on, and the 1 500 W model has a two-heat switch which permits warmth on two 'heat lengths' at the same time.

The commercial models of infra-red heaters are specially designed to blend with all types of décor and are built to the same specification as the domestic heater.

The permanently oil-filled towel rails provide warm dry towels all the year round at the cost of only 0·1 kW an hour. There are three models available in nine colours.

Dimplex Ltd are well-known for their permanently oil-filled thermostatically controlled radiators, of which typical models will be shown. The thermostat makes it possible to select a precise room temperature to suit every day and every season. These radiators are available in a range of nine beautiful colours and in a wide variety of sizes and styles.

Electric Washing Machines

A comprehensive range of electric washing machines will be shown. One model, the Parnall 'Spinwasher', by Radiation International Ltd, is a single tub, semi-automatic washer which washes, rinses and spin dries a 7½ lb (3·5 kg) load of clothes. Wash and spin drying times are set on an 'auto control' which switches the machine off after each 'operation is completed. The attractive sheerline cabinet measures only 36 in (92 cm) high by 22 in (56 cm) square and is designed to match modern kitchen furniture.

The Debonair De Luxe spin dryer manufactured by Simplex Electric Co Ltd is also designed to blend with modern kitchens; maintaining the principle of the original Debonair of making the wash 'ironing dry' in four minutes, the De Luxe also offers many practical refinements. An automatic pump returns water to the washing machine if required.

To complete the home laundry is the 'Parnall' Ezy Press Ironer that will iron everything from sheets to pleats with the minimum of effort.

Of special interest on the English Electric stand will be the latest design in tumble dryers. This machine is fully mobile and can be wheeled to a convenient sink unit, or it can be built in with other kitchen units. The tumble dryer operates by 'tumbling' the clothes in an electrically-driven rotating drum, at the same time drawing a stream of warm air through them. It takes 6½ lb (3 kg) dry weight of clothes. In a small kitchen where there may be ventilation problems, a flexible tube, rather like an elephant's trunk, can be attached to take the damp air out of the window. The machine is controlled by a 120-minute timer switch which automatically cuts off the motor, heater and fan after a pre-selected running time.

New Refrigerators

The English Electric 'Slimline' refrigerators were among the first to show the latest trend for narrow, streamlined cabinets with generous storage space inside. One of the smallest models on show will fit neatly under a draining board, or it can be built in with other kitchen units. Some of the larger models have a 0 deg F (−17·8 deg C) setting for the freezer compartment which allows frozen packaged foods to be kept for several weeks. In most models defrosting is made simple by a push-button control, so that it is no longer necessary to empty the refrigerator of its contents before attempting this operation. Features common to all the types of refrigerators on show are the large freezer compartments, attractive shelving on the doors for bottles and dairy produce and interior lights.

A new refrigerator shown by Tricity Cookers Ltd and which aroused considerable interest since its recent introduction in Great Britain, is the 'Diner-Cold', which has a cabinet finished in highly-polished sapele mahogany veneer.

It thus becomes an attractive piece of furniture that would look well in a dining room, lounge or hall, and will prove invaluable to anyone who has limited kitchen space. This refrigerator is a notable example of contemporary design, combining utility and beauty in one piece of equipment.

Electric Cookers

Electric cookers are being shown in a variety of makes and colours, all of them with pleasant and attractive new features, and a beauty of line to grace any kitchen.

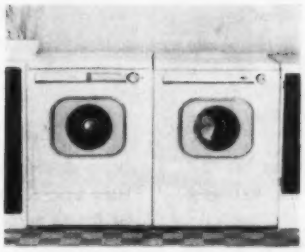
Radiation International Ltd present the Jackson '490' series cooker with modern sheerline styling, eye-level grills, automatic oven control and speedring plates. Full-sized glass doors enable the housewife to keep an eye on the cooking without upsetting the oven temperature by opening the door.

Tricity Cookers Ltd are showing their complete range of domestic electric cookers, including several new models. They include the new 'Marquis', the 'Viscount', the 'Popular'—a small restricted load cooker, and the Tricity 'Built-in' cooker, shown complete with kitchen cabinet units. The 'Viscount' and 'Marquis' cookers are of striking appearance and incorporate a number of special design features. Both models have 7 inch (17·8 cm) 2 kW high-speed radiant plates, with a large independent radiant grill with a loading of 2·2 kW and occupying almost the width of the cooker.

The 'Viscount' has three radiant plates and the 'Marquis' has four; simmer control is fitted to the hot plates and to the grill, so that the latter can also be used as a hot cupboard.

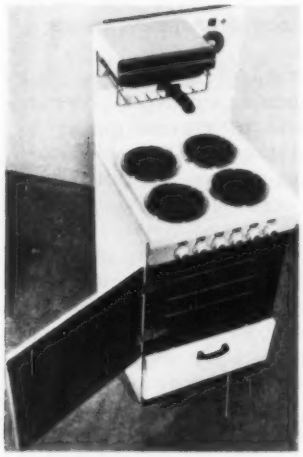
The oven in both models has a capacity of 3 600 cubic

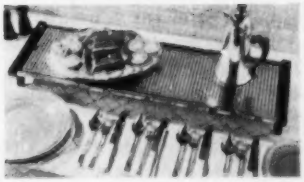
The English Electric Liberator Tumble-Dry clothes drier



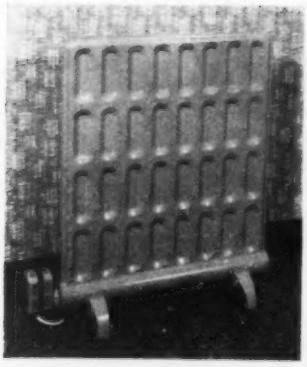
The Liberator Tumble-Dry and the Liberator Washing Machine together make a compact unit

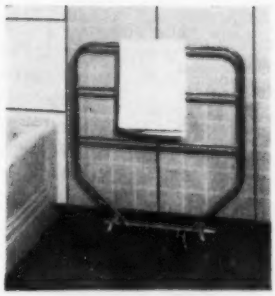
The Liberator Automatic Washing Machine

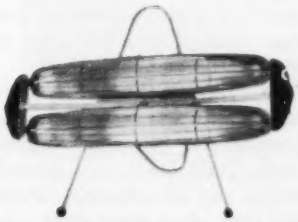




(Left) *The G E C Genalex cooker with eye-level grill and four hotplates*
(Centre) *The Genalex electric firelighter for igniting coal fires quickly*
(Right) *The Genalex warming plate makes a handsome addition to the table*







The 1 500 W Dimplex portable infra-red fire with two-heat switch

The Dimplex 750 W infra-red fire

(Left) *One of the Dimplex range of oil-filled radiators*
(Centre) *The Dimplex Major oil-filled electric towel rail*

inches (59 litres) and has a glass door; in addition the 'Marquis' has an interior oven light.

The Tricity 'Built-in' cooker is made in two parts: (1) an oven and hot-cupboard/grill assembly, and (2) a surface unit with four radiant hot plates and separate control panel. This enables designers and builders to instal the units in any desired position and at any convenient height. The oven capacity is 3 600 cubic inches (59 litres), is thermostatically controlled and has a glass door and automatic interior light.

The Tricity 'Popular' is a compact cooker at an economical price that can be used from an existing 13 or 15 A power point.

English Electric cookers fitted with a control to switch the oven on and off automatically at a pre-selected time, are among the latest cookers shown. Speed on the hob is also taken care of by quick-boil 'Veeline' radiant hotplates with elements shaped like an inverted triangle. These have simmer controls so that heat can be regulated like the volume control of a radio, from very gentle to a rolling boil. The Veeline hotplates are very easy to keep clean as the elements are free from the cradle and the spill-tray is finished in vitreous enamel.

The General Electric Co Ltd are showing a selection from their very large range of domestic electrical equipment. It includes a 'Genalex' cooker with two, three and four hotplates on a unique one-piece design hob. The cooker has an eye-level grill measuring 10½ by 18 inches (27 by 46 cm), full-view glass door, simmer controlled boiling plates, a heated drawer and an automatic timer for the oven.

Under their trade name 'Creda', the Simplex Electric Co Ltd are showing a wide range of appliances.

The 'Creda Mercury Super Four' is an outstanding cooker offering rotisserie cooking with the exciting Creda Rosta-spit. Poultry, joints, kebabs—all done to a turn. Griddle cooking too on the Creda griddle.

Other features of this model are four Creda Quick-Discs, timer control, glass inner door, oven roof grill, oven lighting, and a large plate warming drawer.

The 'Creda Constellation' is a large and luxurious cooker with two ovens (one with a Creda Rosta-spit), two warming drawers, two grills and an extra large hob with four Creda Quick-Discs. Both ovens have glass inner doors and automatic oven lighting. A combined timer control and five-hour ringer are set in a clear easy-to-read panel.

The 'Mercury Super Three' is designed for those who require a hob with three boiling units and all the other characteristic 'Mercury' features: timer control; three Creda Quick-Discs, one specially boosted for extra fast boiling and all infinitely variable in heat control, oven roof grill, glass inner door, oven light, and large plate warming drawer.

Water Heaters

Several types of electric water heaters will be shown by Heatrae Ltd. The 'above-the-sink' model is a very compact unit which gives 18 gallons (82 litres) of water an hour at washing-up temperature. This unit has a very fast recovery rate, being capable of heating the 1·5 gallon (7 litre) capacity to peak temperature in 12 minutes. Fitted with a neon indicator coupled to the thermostat, this heater is fully automatic and very economical in current consumption.

The 'under-the-sink' version is available with alternative sets of taps which give eight different hot-water systems. It has the same characteristics of speed and economy as the model described above, with the added advantage that it can be housed out of sight in the sink unit.

A third Heatrae model is a novel heater which has been developed to give water at hand-washing temperature and to provide for an unlimited number of washes in quick succession. It is therefore particularly suitable for doctors' surgeries, hospitals, schools, shops, cloakrooms and similar locations.

Electric water heaters for commercial use in such establishments as canteens will also be shown.

Electric Fire Lighter

An electric fire-lighter which has no smoke or flame, but which quickly ignites a fire by blowing hot air at a temperature of the order of 1 472 deg F (800 deg C) over the fuel in a grate is a new development shown by the General Electric Co Ltd.

The fire-lighter has a fan similar to a hair dryer which blows air over a 1 800 W heating element. To prevent accidental switching on and to prevent misuse by children, the lighter will operate only by the use of a key.

A warming plate with such an even heat distribution that there is a variation of only 1 deg F (0·6 deg C) in temperature over its whole surface—another notable G E C exhibit. The secret of this warming plate is a printed heating circuit which is sprayed on the underside of the 0·25 in (6·35 mm) thick toughened glass plate.

Among the products shown by the General Electric Co Ltd is a new wall-mounted sanitary towel incinerator. It has been designed for use by as many as 50 women and will therefore prove a valuable piece of equipment for installation by commercial concerns and public health authorities. Its long-life 750 W solid rod element is automatically switched on when the charging door is opened.

An electric toaster which automatically reverses the bread when doors are opened, and a hair dryer of new design in various colours are other exhibits on the G E C stand.

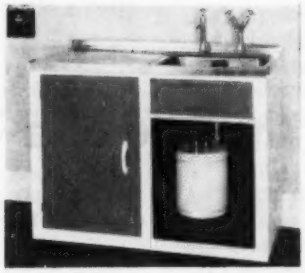
A suction cleaner, the Parnall 'ten-ten' of advanced design, combining portability, super suction and an exclusive air-powered beating action will be one of the exhibits shown. A complete set of cleaning tools in a handy carrier is supplied with every cleaner.

These exhibits are typical of the wide range of the products of the British electrical domestic appliance industry; they provide concrete evidence of the claim that British appliances can challenge comparison with any in the world for attractive design, efficiency and economy.

* * * *

Several of the new appliances mentioned above are described in greater detail in the feature 'New Equipment and Processes' on pages 28 to 31.

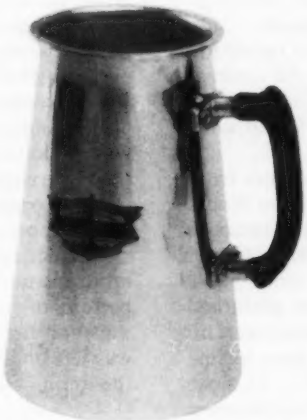
The Heatrae Lido Express water-heater for mounting above the sink



The Lidomat water-heater fitted in a cupboard under the sink and giving automatic control of hot and cold water

An alternative version of the Lidomat water-heater

This Crown Merton porringer can be used with the saucepan shown on the extreme right to make a complete porringer unit



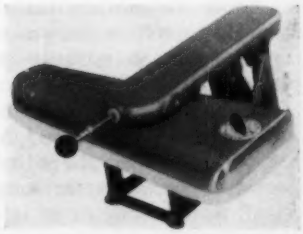
The new model Corfalgar jug, with easy-pour rim

The Crown Merton 6 inch (15 cm) stewpan which, with the pan on the left, makes a dual-purpose unit

The Jackson Highline cooker

The Parnall model EW60H Spinwasher

A suction cleaner of advanced design—the Parnall 'ten-ten'



The Parnall Ezy-Press ironer

Ten Years in the Life of a Transformer

SOME CRITICAL TEST RESULTS

A 100 kVA oil-immersed sealed transformer that had been in service in the Far East for nearly ten years was recently opened up and examined at the Heaton Works of C. A. Parsons & Co Ltd, Newcastle upon Tyne.

In 1950 the Parsons Company supplied to the Shell International Petroleum Co Ltd a batch of fifteen transformers for service in the Far East; these transformers were of the hermetically sealed type. They were installed in an open unprotected situation in the tropical sun and were subjected to fluctuating domestic loads with high peak loading during the daytime cooking periods.

The purchasers were anxious to make an examination of one of these transformers to determine the internal condition after nearly ten years' service and thereby obtain confirmation of the performance of sealed units of this type.

The transformer chosen was selected at random from the batch of fifteen and was returned to the Heaton Works where it was opened up and examined in the presence of a delegation of the Royal Dutch Shell Group engineers.

Although the transformer seal was not disturbed before the visit of the Shell representatives, certain preliminary measurements and preparations were carried out by the makers.

The transformer was heated in an oven to a temperature of about 176 deg F (80 deg C) and measurements were taken during the heating and subsequent cooling cycle of:

(*a*) Top oil temperature.
(*b*) H V winding temperature by resistance.
(*c*) Insulation resistance: H V to L V and earth.
(*d*) Insulation dispersion: H V to L V and earth.

The significant results are as follows:

At 68 deg F (20 deg C) approx: Insulation resistance 6 500 MΩ. Dispersion 16 per cent.

At 176 deg F (80 deg C) approx: Insulation resistance 26 MΩ.

Dispersion Measurements

It should be noted that dispersion measurements provide equivalent information to Schering Bridge measurements of insulation power factor, and that 16 per cent is a very satisfactory reading.

The dispersion was found to increase greatly when the transformer was heated and the value reached was 1 000 per cent. Although large increases in dispersion are known to occur as the temperature of insulation is raised, there is little or no information available in this respect for oily and old transformers, so that no comment can be made on the 'hot' value of dispersion.

While the transformer was hot and thus a positive pressure was presumed to exist in the gas space above oil level, the transformer was thoroughly examined for indications of leakage at all joints, particularly at the cable box bushings. The examination was negative in that no leak was detected.

The transformer had been sealed originally at a temperature of 122 deg F (50 deg C), so that under the conditions of examination a partial vacuum was expected in the gas space. To permit this pressure to be measured before opening to atmosphere a drilling device was welded to the top of the cover. This device contained a $\frac{3}{8}$ inch (9·5 mm) diameter drill, the carrying shaft of which was brought out to atmosphere through a stuffing gland, and from the drill compartment a connection was made to a mercury manometer. The intention was therefore to pierce the cover with the drill and record the internal pressure while the gas space was still sealed from atmosphere.

An additional, and similar, drilling device was welded on to the tank wall as low down as possible, to enable a bottom oil sample to be drawn off at an appropriate stage of the examination procedure. The transformer was left undisturbed for approximately one week before the examination.

Examination Programme

The agreed examination programme was as follows:

Obtain check dispersion reading.
Obtain check insulation resistance reading.
Drill cover and determine gas pressure.
Before opening to atmosphere, draw off sample of gas for analysis.
Remove the drill and check oil level by dipstick.
Draw off top oil samples through drilled hole.
Drill the tank for bottom oil samples and draw off samples.
Chip off the cover and remove.
Inspect transformer and tank before and after removal of oil and removal of the transformer from the tank.

The good outside appearance of the tank was favourably commented upon and it was noted that the devices provided for drilling and sampling operated satisfactorily.

The following comments apply (temperature 66·9 deg F (19·4 deg C)):

Dispersion readings:
H V to L V and earth 14 per cent
L V to H V and earth 12 per cent
Insulation resistances (2 500 V megger, 5-minute values):
H V to L V and earth 7 200 MΩ
L V to H V and earth 7 000 MΩ

Gas pressure negative:
−4·4 in (111·7 mm) mercury, *i e* −2·2 lb/in² (155 g/cm²) gauge or 12·5 lb/in² (879 g/cm²) absolute

Cold oil level correct. (*Note:* The transformer was sealed at 122 deg F (50 deg C) and the position of the 59 deg F (15 degC) cold-oil level mark on the tank had been calculated. The actual oil level was within about ⅛ inch (3·2 mm) of this mark and was thus within the expected precision of oil level adjustment when originally sealed).

There was a trace of oil in one of the tapping switch operating shaft housings on removal of the sealing plug.

Tests on samples of gas and oil drawn off then followed, and gave these results:

The analysis of the gas sample drawn off is given below (percentages by volume):

Carbon dioxide	7·19 per cent
Hydrogen	6·39 per cent
Carbon monoxide	0·48 per cent
Oxygen	18·65 per cent
Hydrocarbons: hydrogen	0·000 2 gm per 788·6 cc
carbon	0·000 8 gm per 788·6 cc
Nitrogen by difference	67·29 per cent

Oil Sample Tests

Tests by C. A. Parsons

The oil samples drawn off were clear and straw in colour. When the first bottom sample was drawn off it was accompanied by some foreign matter, some of which settled to the bottom immediately and some of which stayed in suspension for a few minutes before settling. Since subsequent bottom samples were free from such contamination it is assumed that the first sample was not representative but was contaminated through the drilling and sampling device.

Electrical test results on the oil at room temperature were as follows:

	Resistance by Forrest test set (MΩ)	Breakdown voltage ½ in (12·7 mm) spheres 4 mm gap
Sample from tank bottom	7 000	50 kV after 2 secs
Further sample from tank bottom	6 300	50 kV after 10 secs
Sample from tank top	7 000	50 kV after 4 secs
Further sample from tank top	7 000	50 kV after 3 secs

Note:

1. All samples withstood 30 kV for one minute, followed by 40 kV for one minute. Slight 'pinking' occurred with the second sample during the one minute at 40 kV.
2. For new oil at about 68 deg F (20 deg C) the following approximate resistance values apply:
   - Poor .. up to 1 000 MΩ
   - Fair .. 1 000 to 10 000 MΩ
   - Good .. greater than 10 000 MΩ

Chemical laboratory tests on other samples gave the following results:

	Bottom sample	Top sample
Flash Point (deg F)	300	300
(deg C)	149	149
Acidity (mg KOH/g)	0·375	0·374
Viscosity (Redwood No 1)		
70 deg F (21·1 deg C)	116·2 secs	115·4 secs
100 deg F (37·8 deg C)	63·8 secs	64·0 secs
140 deg F (60 deg C)	44·0 secs	43·7 secs
Moisture (crackle test)	Nil	Nil
Copper	less than 0·1 part S per million	
Iron	less than 0·01 part S per million	

Tests by Thornton Research Centre

(*a*) Appearance of oil: dark yellow and very slightly cloudy. Strong odour very suggestive of the presence of varnish contamination arising from the windings and tank sides of the transformer.

(*b*) Acidity: 0·40 mg KOH/g. From past experience of the examination of oils taken from varnished units which have operated under fairly severe conditions, it was thought that a large part of this acidity arises from the presence of dissolved varnish acids in the oil.

(*c*) B S 148, Oxidation Test:

Sludge, per cent	0·87	0·81
Acidity mg KOH/g	1·00	0·95

(*d*) Electrical properties:

(i) Sample as received

	212 deg F 100 deg C	158 deg F 70 deg C	104 degF 40 deg C
Power factor (50 c/s)	0·025	0·005 2	0·001 1
	0·020	0·004 6	0·000 85
D C resistivity*	0·97	4·2	23
(ohm/cm × 10^{12})	1·1	4·7	27

(ii) After vacuum pre-treatment at 170·6 deg F (77 deg C)†

	212 deg F 100 deg C	158 deg F 70 deg C	104 deg F 40 deg C
Power factor (50 c/s)	0·024	0·005 8	0·001 2
	0·019	0·005 1	0·001 0
D C resistivity*	0·97	3·7	20
(ohm/cm × 10^{12})	1·2	4·5	24

* Measured at a stress of 500 v/mm after stress application of 60 secs.

† Filtration under vacuum.

Internal Condition

The cover weld was then chipped off, the operation taking about one hour, and the cover removed. Inspection of the underside of the cover showed the condition of the internal painting to be as good as new.

Close inspection of the oil surface showed small traces of surface contamination adjacent to the tank walls. These were presumed to be from the varnish coating on the tank and were only distinguishable by careful inspection.

Removal of the core and windings necessitated lowering the oil level to give access to bushing connections. On disconnecting, the through-tank bushings were removed and the Neo-K-Tex gaskets found to be in a sound and pliable condition.

The core and windings, when lifted from the tank, were in a clean condition with no deposits on any of the horizontal surfaces. The windings were of a fairly dark colour but otherwise in new condition.

The end packing of the windings was tight. The off-circuit tapping and series-parallel switches were in sound condition without contamination or surface deterioration.

The inspection showed that the transformer was in excellent condition, and an inspection of the tank after pumping out the oil showed all internal surfaces to be in clean condition. There was no indication of sludge whatsoever.

The tests applied were thorough and in view of the service conditions prevailing, the transformers were considered to have given excellent service over a long period of time.

The Tenth Electrical Engineers Exhibition

THIS annual event, the tenth of the series, will be staged at its usual venue—Earls Court, London, from March 21 to 25, 1961, and will constitute the largest and most comprehensive display of electrical equipment yet staged.

The importance of this exhibition for the trade buyer and the electrical engineer is that it is the only one of its kind in the U K. Visitors from overseas can therefore see under one roof the latest developments in every aspect of the British electrical and allied industry and discuss their requirements with the technical and commercial staffs on the stands.

As in past years, the organisers have undertaken a widespread publicity campaign to attract trade and technical visitors from all over the world, and special facilities will be provided for them at the exhibition itself. Full details of these will be available at the Overseas Reception Room at the main entrance to the exhibition.

As in previous years there will be a special feature on the first floor, and the theme chosen for this year's display is Communications and Signals, with particular emphasis on railway equipment and telephone communications.

The British Transport Commission, in conjunction with British Railways and London Transport, will show by means of models and actual equipment many of the recent developments in the electrical engineering aspects of railway modernisation.

The exhibit will include a model (specially prepared for the exhibition) of the latest overhead equipment, with actual signal-cabin controls installed to operate signalling and track-side electrical equipment, the cabin being built alongside a station platform complete with standard track. The platform will be used to demonstrate the latest types of station illumination, lighting standards and signs.

The railways exhibit will not only be a display of present work, but emphasis will also be given to research programmes on signalling relays, recorders for movement information, controlling equipment for electrical power supply, and many other aspects of communications.

The General Post Office will also make an important contribution to the feature.

Every year the organisers endeavour to show the largest possible reproduction of a component in the exhibition. In 1959 it was a giant electric clock, 60 feet (18 m) in diameter; last year it was the large and impressive electrolier described in our issue of May, 1960.*

This year it is to be the largest moving coil meter ever made, and it will be mounted on the first floor over the main entrance, overlooking the whole exhibition. It will be about 17 feet (5·2 m) square, with a scale length of more than 20 feet (6·1 m). The total weight of the meter will be about 3 cwt (152 kg), of which about one-tenth will be the weight of the magnet, itself nearly 2 feet (61 cm) in diameter. This will drive an aluminium tube pointer, 5 feet (1·52 m) long, and the scale readings will be easily discernible at a distance of more than 100 yards (91·4 m).

The meter will be calibrated from 0 to 5 MW and will show the total electrical load connected during the exhibition—expected to be of the order of 4 MW. It will be connected through a special current transformer to the main intake to Earls Court from the London Electricity Board's supply mains.

The meter has been specially designed and constructed for the exhibition by Nalder Bros and Thompson Ltd.

* THE BEAMA JOURNAL, **67**, No 2, p 52

BEAMA MEMBER-FIRMS IN THE EXHIBITION

A E I (Manchester) Ltd
A E I (Rugby) Ltd
A E I (Woolwich) Ltd
Agro Electrical Co Ltd
Allen West & Co Ltd
Arrow Electric Switches Ltd
Ashley Accessories Ltd
Astral Switchgear Ltd

Backer Electric Co Ltd, The
Bakelite Ltd
Baldwin H. J. & Co Ltd
Belmos Co Ltd, The
Benjamin Electric Ltd, The
Bertram Thomas (Engineers) Ltd
Best Products Ltd
Bill Switchgear Ltd
Bolton Thomas & Sons Ltd
Bonar, Long & Co Ltd
Bonnella, D. H., & Son Ltd
Bray, E. N., Ltd
Bray George & Co Ltd
British Insulated Callender's Cables Ltd
British Power Transformer Co Ltd
Brookhirst Igranic Ltd
Bruce Peebles & Co Ltd
Brush Electrical Engineering Co Ltd
Bryce Electric Construction Co Ltd
Bullers Ltd
Bulpitt & Sons Ltd

Cable Covers Ltd
Carr Fastener Co Ltd
Chamberlain & Hookham Ltd
Chilton Electric Products Ltd
Chloride Batteries Ltd
Cole, E. K., Ltd
Connollys (Blackley) Ltd
Contactum Ltd
Crabtree, J. A., & Co Ltd
Cressall Manufacturing Co Ltd, The
Crompton Parkinson Ltd

D P Battery Co Ltd, The
Dennis, G. P., Ltd
'Diamond H' Switches Ltd
Dimplex Ltd
Donovan Electrical Co Ltd, The
Dorman & Smith Ltd
Dubilier Condenser Co (1925) Ltd

Easipower Appliances Ltd
Electric Construction Co Ltd, The
Electrical Apparatus Co Ltd, The
Electrical Division of Radiation Ltd
Electro Dynamic Construction Co Ltd
Electro-Mechanical Manufacturing Co Ltd
Elliott Bros (London) Ltd
Ellison, George, Ltd
English Electric Co Ltd, The
Erskine, Heap & Co Ltd
Everett Edgcumbe & Co Ltd
Evershed & Vignoles Ltd

Falk, Stadelmann & Co Ltd
Ferranti Ltd
Fibreglass Ltd
Fitzgibbon & Murray Ltd
Formica Ltd
Foster Transformers Ltd

Friedland, V. & E., Ltd
Frost, H., & Co Ltd
Fuller Electric Ltd

G W B Furnaces Ltd
General Electric Co Ltd, The

Hackbridge & Hewittic Electric Co Ltd
Heatovent Electric Ltd
Heatrae Ltd
Heenan & Froude Ltd
Higgs Motors Ltd
Hoover Ltd
Horstmann Gear Co Ltd, The
Hunt, A. H., (Capacitors) Ltd
Hurseal Ltd

International Rectifier Co (G B) Ltd
Ioco Ltd
Isopad Ltd

Johnson & Philips Ltd

Lancashire Dynamo & Crypto Ltd
Lancashire Dynamo Electronic Products Ltd
Lancashire Dynamo Nevelin Ltd
Langley London Ltd
Laurence, Scott & Electromotors Ltd
Limit Engineering Group Ltd
Line Equipment Ltd
London Electric Wire Co & Smiths Ltd
London Transformer Products Ltd
Long & Crawford Ltd
Lucy, W., & Co Ltd

Maclaren, Robert, & Co Ltd
Mawdsleys Ltd
M & C Switchgear Ltd
M C B Co (Manchester) Ltd, The
M K Electric Ltd
M T E Control Gear Ltd
McGeoch, William, & Co Ltd
Metal Industries Group
Micanite & Insulators Co Ltd, The
Midland Electric Manufacturing Co Ltd
Miller, Gordon, Ltd
Morecambe Electrical Equipment Co Ltd
Morgan Crucible Co Ltd, The
Morphy-Richards (Cray) Ltd

Nalder Bros & Thompson Ltd
National Pressure Cooker Co (England) Ltd
Nettle Accessories Ltd
Newman Industries Ltd
Newton Bros (Derby) Ltd

Ottermill Switchgear Ltd

P & B Engineering Co Ltd, The
Parmiter, Hope & Sugden Ltd
Partridge, Wilson & Co Ltd
Permali Ltd
Petbow Ltd
Philips Electrical Ltd
Pinchin, Johnson & Co Ltd
Pirelli-General Cable Works Ltd
Prichett & Gold & E P S Co Ltd
Process Control Gear Ltd

Record Electrical Co Ltd, The
Remploy Ltd
Revo Electric Co Ltd
Reyrolle, A., & Co Ltd
Rheostatic Co Ltd, The

Sangamo Weston Ltd
Santon Ltd
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Scholes, Geo. H., & Co Ltd
Shell Chemical Co Ltd
Siemens-Schuckert (G B) Ltd
Simplex Electric Co Ltd
Smith Meters Ltd
Smiths Clocks & Watches Division Ltd
South Wales Switchgear Ltd
Square D Ltd
Standard Telephones & Cables Ltd
Statter, J. G., & Co Ltd
Steatite & Porcelain Products Ltd
Switchgear & Cowans Ltd
Symons, H. D., & Co Ltd

Taylor, Tunnicliff & Co Ltd
Temco Ltd
Thermair Ltd
Thermalay Domestic Appliances Ltd
Tricity Cookers Ltd
Tufnol Ltd
Turners Asbestos Cement Co Ltd

Wallacetown Engineering Co Ltd
Walsall Conduits Ltd
Wandsworth Electrical Manufacturing Co Ltd, The
Watford Electric & Mfg Co Ltd
Westinghouse Brake & Signal Co Ltd
Whipp & Bourne Ltd
Woden Transformer Co Ltd

Yorkshire Switchgear & Engineering Co Ltd

Railway Modernisation Conference: May 3 and 4, 1961

PROMOTED jointly by the Institutions of Civil, Mechanical and Electrical Engineers, a conference will be held in London on May 3 and 4 next. This follows up the successful British Railways Conference held in October of last year* dealing with the 25 kV system of railway electrification.

It is felt however, that this represented only one aspect of the comprehensive modernisation of the British Railways network, and the stage has now been reached when it is possible to give an authoritative account of the extensive civil, mechanical and electrical engineering works carried out during the past five years.

The forthcoming conference has therefore been arranged to give engineers both in the United Kingdom and overseas countries an opportunity to discuss the project and the lessons learned. The Presidents and Councils of the three Institutions concerned would welcome participation in the conference by members of the staffs of railway organisations overseas.

No registration fee will be charged, and application forms to attend the conference can be obtained from the Secretary, Institution of Civil Engineers, Great George Street, London, S W 1.

* THE BEAMA JOURNAL, **67**, No 4, pp 153–171

The following papers will be presented for discussion:

The Engineering Aspects of the Modernisation Plan for British Railways
R. C. Bond, M I C E, M I MECH E, Technical Adviser, British Transport Commission.

The Contribution of Civil Engineering to the British Railways Modernisation Plan
M. G. R. Smith, M B E, B SC, M I C E, Chief Civil Engineer, Western Region, British Railways.

The Impact of Mechanical Engineering on the British Railways Modernisation Plan
J. F. Harrison, M I MECH E, Chief Mechanical Engineer, British Railways Central Staff.

Electric Traction in the British Railways Modernisation Plan
S. B. Warder, M I MECH E, M I E E, Chief Electrical Engineer, British Railways Central Staff.

British Railways Modernisation—Signal Engineering and Telecommunications
J. F. H. Tyler, B SC, M I R S E, Chief Signal and Telecommunications Engineer, Southern Region, British Railways.

Advance copies of papers will be available in the first week of April, 1961, and will be sent to all who have indicated their desire to attend.

The conference arrangements include an exhibition, and visits to railway and manufacturers' works can be arranged to meet the needs of overseas visitors.

The Economics of Railway Electrification

EDITOR'S NOTE. *The following is the text of a talk given by Mr Ray Thomas, Economic Intelligence Officer, British Filters Ltd, and formerly of the National Institute of Economics and Social Research. His talk was broadcast by the British Broadcasting Corporation in the Network 3 programme on January 15, 1961.*

It is reproduced here by kind permission of the author and the B B C, as we think it will be of interest to many of our readers overseas who are concerned with railway operation in their own countries and who are closely watching the progress of railway electrification in Britain.

SOMETIME this year we shall be using only half as many steam locomotives as we did in 1955. Should they be replaced by electrification or diesel traction?

The short answer is that it depends on the traffic density. Diesels are more economic where traffic is light and electrification where it is heavy. Electrification is more expensive to install, but given a certain traffic density is cheaper to run.

It is important to distinguish between the costs of improving the track and the costs of changing the means of traction from steam to electricity or diesels. Where lines carry little traffic, diesels can be usefully employed without track improvements. Railbuses, diesel multiple units, or diesel locomotives can maintain existing services far more cheaply than the old steam locomotives which they replace, and electrification does not enter into the picture at all. Where lines carry heavy traffic a major initial cost is the improvement of the track to make faster and more frequent services possible. But on British railways we are at last having to pay for thirty years of neglect, and this outlay has to be made whether the line is to be electrified or run by diesels. The recent discussion has been about whether these modernised lines justify the extra capital cost of electrification.

Traffic Density as a Criterion for Electrification

The first question to ask is what level of traffic density would justify considering electrification? An official committee reported in 1951 that electrification is economic when a line carries between 3 and 4 million trailing tons a year, although an extension of an existing scheme may be justified by a lower figure. Thirty per cent of our lines carry more than 5 million trailing tons and the Euston-Manchester lines carry 9 million—probably the heaviest loads in the world.

The second major factor is capital costs. Electrification needs a larger outlay than the introduction of diesels because, although the power units cost less, the power supply installation costs considerably more.

A main-line electric locomotive costs about £80 000, while a comparable diesel locomotive £110 000. Electric locomotives are also more economic because of their superior performance; they can accelerate faster, they have a better power-to-weight ratio, they are more reliable, and they have a higher availability—that is the proportion of their life they can spend in useful service. Because of these factors a larger number of diesels than electrics is needed to do the same work. At present we do not know exactly how many.

I would like to digress for a minute because after last month's withdrawal of the Glasgow services it may seem strange to assert that electrification is more reliable. But remember that this scheme is the world's first example of 25 kV multiple unit trains on lines carrying such heavy traffic. Because we are electrifying most of our lines comparatively late we can take full advantage of the most recent technical developments, but we also run the risk that we must pay the cost of teething troubles when we apply them.

Power Supply can be a Major Item of Cost

A major part of the cost of electrification is the power supply—the third rail or overhead wire and the transforming substations. The cost of this power supply for the London-Midland line is estimated at about £6 000 a mile. The 25 kV electrification (now the standard adopted for all lines in this country except the Southern Region) requires an 11 inch (28 cm) clearance between the overhead wire and the train. This can be a major additional item of expense. In the case of the Euston-Liverpool lines the reconstruction of bridges and tunnels will cost £9 million. For diesel traction the only cost corresponding to these is the provision of refuelling depots, and in comparison this is obviously very small.

The third major factor is running costs. There is no difference for crewing—both electric and diesel trains can be manned by one person only, and there is little difference in present energy costs.

We know that repair and maintenance costs for diesels are higher. There is the cost of refuelling and, because a diesel engine is mechanically more complex than a transformer or rectifier, it will always require more attention.

The comparative cost of depreciation is less certain. Present estimates give similar depreciation charges for electric and diesel locomotives. They are both assumed to have a useful life of 30 years. But this figure seems very doubtful for diesels in the light of American experience, and I shall return to this point later.

You may well say after this wealth of detail that most of the factors I have mentioned are rather technical and I have given no indication of their relative importance. I can only plead that the statistics for our railways are not available. Summary figures have been given for the East Coast main line. For the line from King's Cross to Newcastle the outlay for diesel traction would be between £10 and £20 million less than for electric, and the running cost between £1 and £3 million a year more. If for the sake of discussion we take the figures mid-way between these limits, we can say tentatively that electrification would cost less after seven or eight years.

If it is only a matter of time before electrification is cheaper, why have the railways bothered with diesels at all? The answer is not only that electrification requires more outlay, but it also takes longer to install and installation interferes with existing services. Diesels are a useful means of quickly introducing a cheaper modernised service. When the lines are eventually electrified the diesels can simply be transferred to lines where the traffic density does not justify electrification.

The Probable Effect on Revenue of Modernisation

So far I have only considered costs. What are the effects of replacing steam locomotives on revenue? Here it is difficult to compare diesels with electrification. The difference between them in the standard of service they can provide is much smaller than the difference between diesels and steam. In any case the railways are a single entity and it is impossible to discover the increase in revenue for traffic which started or finished its journey outside a modernised area. The statistics which are published relate only to local passenger journeys and exclude season tickets. For all these reasons they should be used to illustrate rather than to compare.

The main electrification scheme for which figures are available is for the line from Liverpool Street to Shenfield and the subsequent extensions to Chelmsford and Southend. After two years of electrification, journeys were 12 million up on the last year of steam operation —an increase of nearly 80 per cent. Diesels have been introduced on lines where the traffic is much lighter. The corresponding total for six different diesel schemes is only 4 million, but this is an increase of more than 200 per cent.

In a free economy it is impossible to make precise forecasts. Future revenue from freight probably depends mainly on the growth of 'C' licences; from passengers it depends upon the spread of ownership of cars, and from both it depends upon the severity of road congestion. But I think these figures illustrate clearly that modernisation can lead to substantial increases in traffic and bring it to the levels which particularly favour electrification.

Because of the lack of knowledge of diesel traction in this country, it is useful to consider the experience of the U S A where diesels have predominated for some years. A recent study concluded that if the diesels on the American railways were replaced by modern steam locomotives, total costs would actually fall. Most of the factors making for this startling assertion do not apply to this country, but two figures are relevant. Diesels were found to have a useful life of only 12 to 18 years—roughly half the life of electric locomotives. Repair costs over this comparatively short life were more than three times those of electric locomotives and account for a quarter of the total cost of running the diesels.

Experience of Electrification in European Countries

It is not surprising therefore that most European countries, which do not have their own oil, have gone in for electrification. It is difficult for a variety of reasons to make any significant comparisons of productivity with these countries. But France, West Germany, Belgium, the Netherlands and Switzerland all have far higher productivity, measured in passenger and ton-miles per member of railway staff, than the U K. The differences are greatest for the Netherlands and Switzerland where electrification has gone furthest. The differences are not significant when the comparison is made with the Southern Region alone, where nearly half the track is electrified. I would emphasise that comparisons of this kind cannot be taken as indicating differences in efficiency, but I do think that they are in some way associated with the amount of electrification.

Finally, I would like to quote the summary of a report on Swiss Railways, which are unique in being completely electrified.

'Taking into consideration all that is directly or indirectly involved, a hypothetical operation of Swiss railways by diesel traction would be about twice as expensive as the application of electricity. A hypothetical steam operation, if it were possible at all, would cost three times as much'.

Of course most of the Swiss railways have been electrified for some time and they work under very different conditions. But I would add, as my personal comment, that Swiss railways make a handsome profit.

* * *

In a discussion following the talk, some questions were put to M Pierre Weil, the Chief Press Officer of the French Railways. The replies given by M Weil showed that the points made by Mr Thomas have been fully confirmed by actual operating experience of the electrified system of the French Railways.

Electricity's Contribution to Comfort at Sea

THE P & O Orient liner *Oriana* which recently made her maiden voyage to Australia has been described as '40 000 tons of efficiency and beauty'. Launched in 1959 by H R H Princess Alexandra at Barrow-in-Furness, she is the biggest ship ever to be built in England.

The vessel is propelled by twin screws, each driven through double reduction gearing by a set of steam turbines. The total normal service shaft horse power is 65 000 at 147 propeller revolutions per minute and the total maximum designed shaft horse power is 80 000 at 157·5 propeller revolutions per minute.

Steam is supplied to the turbines at a pressure of 700 lb/in² (49 kg/cm²) and at a temperature of 950 deg F (510 deg C).

While warming up or cooling down, the turbine rotors are protected by A E I automatic turning gear. An electric drive, hydraulically controlled from the main manoeuvring platform, turns the rotors very slowly and thus prevents the distortion that could be produced by warming or cooling in a stationary condition.

W. H. Allen Sons & Co Ltd supplied the main and auxiliary turbogenerators, together with circulating pumps, sanitary pumps and bath pumps.

The oil-burning installation, consisting of four pumping and heating units, was installed by Joseph Lucas Ltd. Only three of these units are required to be in use at maximum power. Each consists of a low-pressure and high-pressure pump and low-temperature and high-temperature heater.

Nearly 300 miles (483 km) of ship wiring cables have been used in the *Oriana*—nearly enough to provide a direct cable link between London and Cologne. This was supplied by British Insulated Callender's Cables Ltd, who also supplied all the copper section for the busbar installation.

The 200 kW emergency diesel generator located on 'C' deck

The majority of the cables supplied by B I C C are of the V R I heat-resisting type, though many thousands of yards of varnished cambric and mineral insulated cables have been installed.

Amenities for Passengers

The *Oriana* will carry over two thousand passengers who will travel in the greatest comfort. For refrigeration and air-conditioning purposes, A E I have supplied four refrigeration compressors driven by four 550 h p back-pressure steam turbines, each unit rated at 6 million B t u/h r. In addition, 30 motors of various sizes totalling 1 100 h p are installed, and the air-conditioning system requires 130 fans with a total of 650 h p.

sizes totalling 1 100 h p are installed, and the air-conditioning system requires 130 fans with a total of 650 h p.

A 500-line manual telephone exchange covers every first-class cabin and pantry, ensuring an efficient steward service to passengers. Twelve shore connections are provided for linking ship to shore when the vessel is in port. An automatic telephone exchange of 120-line capacity is fitted for staff communication.

There are 125 electric clocks of the impulse type fitted throughout; these are controlled from a master clock on the bridge which is in turn controlled by two 8-day chronometers.

Lighting plays an important part in the ship, with over 2 500 sockets and 15 000 lighting fittings. These fittings, together with 700 telephones, 500 bell pushes and other electrical appliances, form a most impressive installation.

The *Oriana* has 13 lifts of varying types, from the conventional passenger lift to a small service lift for the removal of garbage from the galley. It is interesting to note that the overall travel of some of the lifts is greater than in some modern hotels. In some cases the ship's lifts serve ten decks—a distance of more than 70 feet (21 m).

Unique Television Installation

Passengers in the *Oriana* will be able to enjoy local television programmes at ports of call, and closed-circuit teleciné and live television programmes while the ship is on the high seas.

This will be the first passenger vessel in the world to be equipped with a completely co-ordinated internal and broadcast television service. The order for the entire system was negotiated by the Marconi International Marine Communication Co Ltd, acting on behalf of Marconi's Wireless Telegraph Co Ltd, who have designed and engineered a unique marine television installation enabling standard and unmodified television broadcast receivers to be used for reception of local transmissions in any part of the world where a television service exists.

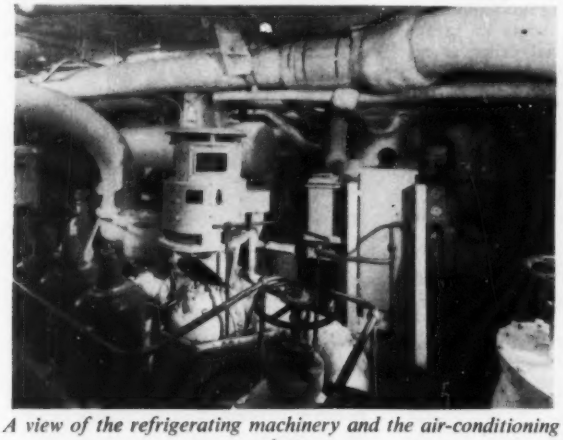
The installation provides for the reception of television broadcasts employing the 405-line system used in Britain, the 625-line system used in Australia and the greater part of Europe, and the 525-line system used in Canada, the U S A and Japan.

Initially, some 60 receivers will be installed in public rooms and first-class cabins, and provision is being made for increasing the number at a later date up to a maximum of nearly 400 without any alteration to the basic installation.

Kitchen Equipment

Cooking equipment of the highest quality is installed on the vessel. The *Oriana* is equipped with electrically-heated and steam-heated hotpresses, 'Orient' type electric grills, charcoal grills, salamanders, hotplates and tilting type stockpots.

All hotpresses are made from stainless steel, and a special feature is that the interiors are of drum construction with all corners radiused; they are thus extremely hygienic as there are no crevices where particles of food can lodge. Exceptionally heavy copper coils of 14 swg (2 mm) are fitted in the steam hotpresses, and 'Wilson-BTH Pyrobar' sheathed type elements in the electric hotpresses. In one particular department lowerator plate dispensers are fitted to the hotpresses and special precautions have been taken in regard to heating the plates contained in the lowerators.



A view of the refrigerating machinery and the air-conditioning plant

The electric grills are of the latest design, heated by Pyrobar elements, and having their controls fitted into the front of the plate. The electric salamanders are installed in various parts of the ship and here again the interiors are of drum construction in the interests of cleanliness.

A feature of the fryers is that they are heated by 'Wilson-BTH Pyrobar' over-the-top type of elements which are directly immersed in the fat. These can easily be withdrawn and swung to one side for cleaning of the pan. As on all modern ships, the pans are thermostatically controlled.

The tilting stockpots throughout the ship are fitted with balanced covers and the smaller capacity (20 gallons—91 litres) have their framework made from stainless steel tubing.

Where the apparatus is fixed to the deck, an unusual feature is that all legs are of stainless steel tubing of ample strength which, for installation purposes, engage in pegs projecting from the deck.

Electrical services also include the various navigational controls in the wheelhouse, and a conveyor belt system

The Princess Room, named after H R H Princess Alexandra. This is one of the largest of the first-class public rooms in the ship

for moving heavy luggage between the baggage room and the loading and unloading apertures in the ship's side. Other facilities are the two cinemas, a laundry and launderette, and a general hospital. Universal razor socket outlets are provided in every cabin.

From a passenger's point of view, the *Oriana* with all her modern features offers the perfection of comfort and convenience which only electricity can provide. Technically, she is an outstanding example of British electrical engineering practice.

Member-firms of The BEAMA associated with the building and equipping of the *Oriana* are as follows:

A E I Ltd (*Automatic Turning Gear for Main Engines*); W. H. Allen Sons & Co Ltd (*Turbo-Generators and Circulating Pumps*); Babcock & Wilcox Ltd (*Desuperheaters*); Birmingham Battery & Metal Co Ltd (*Copper Nickel Iron Sheets*); Bakelite Ltd (*Metal Reinforced Aluminium Sheet*); British Insulated Callender's Cables Ltd (*Cables and Busbars*); Britmac Electric Co Ltd (*Switch Sockets*); Cambridge Instrument Co Ltd (*Thermographs for Main Steam*); Carron Co (*Aluminium Sidelights*); Chilton Electric Products Ltd (*Electric Razor Sockets*); Curtis Manufacturing Co Ltd (*Charging Resistors*); Drysdale & Co Ltd (*Pumps and Fans*); Elliott Bros (London) Ltd (*Thermometers for Distance Reading*); Evershed & Vignoles Ltd (*Rudder Indicator*); Fibreglass Ltd (*Thermal Insulation*); General Electric Co Ltd (*Lighting Fittings and Telephone Exchange*); Heatrae Ltd (*Space Heaters*); Ioco Ltd (*Soft Plastic linings*); James Howden & Co Ltd (*Induced and Forced Draught Fans*); Joseph Lucas (Hydraulic & Combustion Equipment) Ltd (*Oil-Burning Equipment*); Laurence, Scott & Electromotors Ltd (*Motor Alternators*); Mather & Platt Ltd (*Sprinkler System*); Parkinson Cowan Measurement Ltd (*Dynamo Oil Fuel Pump*); Wm. McGeoch & Co Ltd (*Lighting Fittings*); C. A. Parsons & Co Ltd (*Turbine Blading*); Redifon Ltd (*Communal Aerial System*); Standard Telephones & Cables Ltd (*Cables*); Santon Ltd (*Switches*); Stewart & Lloyds (*Brine Piping*); G. & J. Weir Ltd (*Closed Feed Auxiliary and Distilling Plant*); Wallace & Tiernan Ltd (*Chlorinating Plants for Swimming Pools*); Whipp & Bourne Ltd (*Main Emergency and Auxiliary Switchboard*); Yorkshire Imperial Metals Ltd ('*Yorkshire*' *High-Duty Fittings*).

New equipment and processes

The Parnall Wringer-Washer

From the Electrical Division of Radiation Ltd comes a new wringer-type washing machine which can be supplied as a non-heated version (EW52) or a heated model (EW52H) incorporating a 3 kW immersion heater.

The machine is designed in a sheerline contemporary style, with the controls for the agitator, pump and heater grouped in a central control panel. It has a capacity of 6½ lb (3 kg) of dry clothes; it is fitted with a reversible power-operated wringer and an automatic emptying pump through a removable outlet pipe.

The over-all height of the machine is 33·7 inches (86 cm), which allows the washer to be stored beneath a draining board or a kitchen working surface. When in position for use, the wringer overhangs the sink and permits clothes to be wrung directly into the sink; the wringer can then be swivelled between the sink and the draining board. Stowage for the wringer is provided in a compartment within the cabinet, and the machine is mounted on four swivel wheels. The cabinet is finished in high quality cream or white stove enamel, and the inner clothes tub is finished in two-coat vitreous enamel.

Models are available for operation on all standard a c voltages. A table top is available as an optional extra. (*Radiation International Ltd*, 255 North Circular Road, London, N W 10.)

The Parnall power-operated wringer-washer described above

Two New Dimplex Electric Towel Rails

Two new models have recently been added to the range of permanently oil-filled electric towel rails made by Dimplex Ltd. They are known as Models TRC/130 and TRS/175.

These new towel rails have been designed to fit into the smallest bathroom and yet give the maximum towel hanging space. They are the same height as the largest Dimplex towel rail but only 21 inches (53 cm) wide. An additional cross bar, however, gives the towel rail the same hanging space as the larger model within very much smaller overall dimensions.

They are available for either floor or wall mounting. The chrome model (TRC/130) is loaded at 130 W and the stove-enamel model (TRS/175) is loaded at 175 W. There is a choice of nine colours in the stove-enamel finish—white or cream as standard or (to special order at no extra charge) turquoise blue, pink, eau-de-nil, light grey, red, black and bronze.

With the addition of these two new models, Dimplex claim that they now have a towel rail to meet every requirement. Of the other models, TRC90 and TRS120 are the smallest of the Dimplex range and have been designed for the very small bathrooms which are often found in modern homes. They are available for wall mounting only and are also suitable for fitting to the end of a standard kitchen sink unit.

The chrome model (TRC90) is loaded at 90 W and the stove-enamel model (TRS120) is loaded at 120 W.

Models TRC150 and TRS200 are the largest models in the range and have over 7 feet (2 m) of towel hanging space. They are available with either feet or wall brackets. The chrome model (TRC150) is loaded at 150 W, the stove-enamel model (TRS200) is loaded at 200 W. (*Dimplex Ltd*, Millbrook, Southampton.)

Crompton Parkinson Fluid-filled Radiator

This recent introduction represents a new development on the part of the old-established Crompton Parkinson firm. In designing this new 'Commodore' radiator, the makers have aimed at complete safety and trouble-free operation combined with a high degree of versatility in its use.

The radiator has a 1 kW immersion heating element sealed inside a fluid-filled body styled on slim modern lines and measuring 27 inches (68 cm) high, 32 inches (81 cm) wide and 6⅝ inches (16·8 cm) deep, on its free-standing base. Without the base it is 24½ inches (62 cm) high.

It can be used as a portable radiator or fixed permanently against a wall with equal assurance of safety. When wall-mounted with the brackets and deflector plate supplied, its depth is only 3½ inches (8·9 cm).

The 'Commodore' radiator is thermostatically controlled, the thermostat being governed by the radiator temperature. It has a simple finger adjustment with an upper limit corresponding to a radiator surface temperature of 170 deg F (76·7 deg C). Because of its fluid filling the whole surface of the radiator assumes the same temperature; there are no localised sources of intense heat. It is claimed that a single radiator will, in normal circumstances, maintain 1 000 cubic feet (28 m³) of space at a comfortable, even temperature.

A novel feature is that each side of the radiator is coloured differently and there are three distinctive colour combinations available: gold and bronze, mid-grey and pink; eau-de-nil and cream.

Operation is on 230/250 V a c mains only; the design and construction comply with British Standard requirements, and the radiator is guaranteed for 12 months.

A double towel rail for use with either the free-standing or the wall-mounted model is available as an optional extra. (*Crompton Parkinson Ltd*, Crompton House, Aldwych, London, W C 2.)

The free-standing version of the new Commodore fluid-filled radiator

New Mazda Fluorescent Lamp

Recently introduced is the Mazda 'Kolor-rite fluorescent lamp, which is claimed to give the nearest approach to daylight yet achieved by lamp makers.

A E I lamp designers describe the light given by the new 'Kolor-rite tube as in the noon sunlight region, which has a reasonably consistent spectral distribution. Tungsten lamps, as is well known, give a light with an uneven spectrum—weak in blue and strong in red. Earlier fluorescent lamps were criticised as being 'cold' and unflattering, and many of the later types have usually been designed to produce a pleasing light rather than an exact copy of natural daylight.

'Kolor-rite lamps have been exhaustively tested by colour experts and it is reported that their light accurately renders the colours of all types of merchandise, including foods and even notoriously difficult textiles without undue emphasis or deadening of any one colour.

The lamps are available in two types: 5 feet (152 cm) 80 W, with bayonet or bi-pin cap, and 4 feet (122 cm) 40 W with bi-pin cap only. Estimated life is 5 000 hours; average output 2 560 and 1 360 lumens respectively. (*A E I Lamp and Lighting Co Ltd*, Melton Road, Leicester.)

Two Electric Shaver Supply Units

These two Chilton units, which have several distinctive features, are intended respectively for installation in the home and in commercial premises. Both are designed to provide a convenient source of power at the right voltage rating with maximum reliability and proper built-in safeguards.

Known as the Chilton Mark IV Electric Shaver Supply Unit, the domestic version is a single-voltage unit, and the commercial version is a dual-voltage unit. Both incorporate a multi-pin single socket outlet which is stated to accommodate most shaver plugs of British, U S A and European make. The dual-voltage unit provides either 230 or 115 V a c by a voltage selector switch; the single-voltage home model provides a 230 V a c supply only, the switch in this case giving 'on' and 'off' positions.

Both units incorporate a 20 W double-wound transformer, providing an earth-free a c supply at mains frequency. A self-resetting thermal trip in the input to the transformer protects the unit from overheating and damage if equipment with a higher rating should be plugged in.

The units are of contemporary design in grey plastic and are suitable for flush or semi-flush wall mounting. Both types are similar in shape and size; overall dimensions are 5¼ inches (13·3 cm) high, 3¾ inches (9·5 cm) wide, and $\frac{9}{16}$ inches (14 mm) deep—the last dimension being that of the outer shell only.

Chilton, who hold the master patent for shaver supply units, have equipped leading hotels, office blocks, railways, airports and shipping lines throughout the world, including the s s *Oriana*, described on pages 26–27 of this issue. (*Chilton Electric Products Ltd*, Hungerford, Berkshire.)

The Chilton Mark IV dual-voltage shaver supply socket for commercial use

Three New Slimline Refrigerators

To meet the demand for larger, family-size refrigerators, English Electric have announced a 6 cubic feet (170 litre) model, Slimline 60, as one of three new additions to their Slimline range for 1961. The others are a 7·7 cubic feet (218 litre) model (Slimline 77) and a 9·4 cubic feet (266 litre) model (Slimline 94). A special feature of these latest refrigerators is a full-width deep-cold freezer. With a white exterior and an interior colour scheme of glacier and arctic blue, the new models continue the Slimline theme of elegant square-cut design, trimmed to minimum overall measurements yet giving the maximum internal storage space. They all have an automatic interior light and the two larger models have automatic push-button defrosting.

The cabinets are of one-piece welded construction in heavy gauge high quality steel, rust-proofed and finished in stoved enamel and thermally insulated with glass fibre. Doors are of rust-proofed pressed steel finished in stoved enamel. They have a pull-open latch and chromium-plated handle (models 77 and 94 have a lock) and are fitted with egg rack, dairy-keeper with spring-loaded door, and shelves with silver anodised aluminium guard rails. Levelling screws are fitted to the base of the cabinet.

The food compartment is a one-piece plastic moulding with a 15 W automatic interior light. White plastic-coated steel-rod shelves are adjustable on the two larger models.

All models have a full-width aluminium freezer with insulated moulded polystyrene door. The freezer provides low temperatures from 15 deg F (− 9·4 deg C) to below 0 deg F (−17·8 deg C)—suitable for storing frozen foods up to three weeks, and even three months if certain precautions are taken with the food while defrosting.

Models 77 and 94 have a defrosting button in the centre of the temperature control dial. When the button is pressed, the refrigerator motor stops and defrosting begins; when defrosting is complete, the motor automatically starts and frosting begins again.

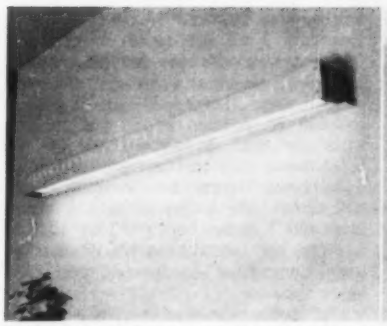
The salad crisper is a full-width drawer which is fitted with a glass moisture-retaining cover which also serves as an additional shelf.

The refrigerating unit consists of a hermetically-sealed reciprocating compressor charged with Arcton 12 refrigerant, and a $\frac{1}{8}$ h p induction motor with automatic thermal overload protection. Two models are available: for 200/250 V 50 c/s or 115 V 50/60 c/s.

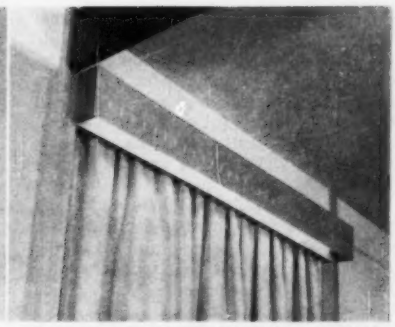
Measurements are as follows:

	Slimline 60	Slimline 77	Slimline 94
Gross capacity:	6·0 cu ft 170 litres	7·7 cu ft 218 litres	9·4 cu ft 266 litres
Freezer capacity:	0·43 cu ft 12 litres	0·77 cu ft 22 litres	0·91 cu ft 26 litres
Shelf area:	10·3 sq ft 9 569 cm²	11·78 sq ft 10 870 cm²	13·15 sq ft 12 170 cm²
Height:	41½ in 106 cm	46½ in 118 cm	54 in 137 cm
Width:	22½ in 57 cm	24 in 61 cm	24 in 61 cm
Depth:	25¾ in 65 cm	27½ in 70 cm	27½ in 70 cm
Net weight	140 lb 63 kg	160 lb 72 kg	178 lb 80 kg

(*The English Electric Co Ltd*, English Electric House, London W C 2.)



This Atlas 'A-Plan' fitting is designed for wall mounting and can be used in a variety of ways



Close-up view of another Atlas 'A-Plan' fitting showing how it may be used effectively for curtain illumination

Atlas 'A-Plan' Lighting

Ingenious and imaginative design have combined to produce the highly versatile, decorative and inexpensive series of fluorescent light fittings just introduced by Atlas under the name of 'A-Plan'.

For domestic applications, the fittings are extremely versatile and can be used for pelmet lighting, bookcase lighting, picture lighting, and alcove lighting, while some of the fittings are particularly suitable for the illumination of mirrors, dressing tables writing desks, etc. To complete the system, an unusual and attractive fabric-covered fitting has been designed for use as a bedhead light. Other applications can be found in corridor, room and foyer lighting for hotels, reception areas in office buildings, showrooms and stores.

Altogether there are six basic types of 'A-Plan' fittings:

Type LFS, available in either 4 ft (122 cm) 40 W or 5 ft (152 cm) 80 W sizes, has a slotted metal reflector with Scandinavian wooden end panels and is designed to fit direct to the ceiling and give a downward light. The 4 ft (122 cm) size is in a choice of four colours: white, black, tangerine and mushroom; the 5 ft (152 cm) size is available in white, black or mushroom.

The LES series, available in 2 ft (61 cm) 20 W, 4 ft (122 cm) 40 W and 5 ft (152 cm) 80 W sizes, has a slim metal reflector with Scandinavian wooden end panels, throwing light upwards and downwards and is designed specifically for wall mounting. The 2 ft (61 cm) version is available in either white or mushroom; the 4 ft (122 cm) fittings in either white, tangerine or mushroom, and the 5 ft (152 cm) version in either white or mushroom.

The LDS series has a slotted metal trough reflector giving downward light only and, like the LES fitting, is intended for wall mounting. The 2 ft (61 cm) version is available in either white or tangerine; the 4 ft (122 cm) version in white, black, tangerine or mushroom, and the 5 ft (152 cm) version in white, mushroom or black. Both the LES and LDS fittings are especially suitable for picture, pelmet and bookcase lighting, etc.

The HDK/KN fitting is a wall-mounted fitting with a shielded plastic diffuser giving downward and horizontal light, and is available in 2 ft (61 cm) and 4 ft (122 cm) sizes. A pull switch assembly for use with

this fitting can be purchased as an optional extra.

The HDK/KW fitting for ceiling mounting has a decorative clip-on diffuser in extruded plastic with blue end panels, and is available in 2 ft (61 cm), 4 ft (122 cm) and 5 ft (152 cm) sizes. This fitting is suitable for a variety of general lighting applications.

The HDK/LA12 is a 2 ft (61 cm) fitting with an attractive patterned fabric diffuser with wooden end pieces, and is ideally suitable as a bedhead light. (*Atlas Lighting Ltd*, Thorn House, Upper St. Martin's Lane, London, W C 2.)

This model of the G E C Treasure cooker has four Superspeed boiling plates and oven timer

Modern Low-cost Cooker by G E C

Up-to-the-minute styling at low cost is provided by a new G E C cooker known as the Treasure. It has an eye-level grill, full-view glass door, simmer-controlled Superspeed boiling plates, a heated drawer and, on one model, an auto-timer for the oven.

The three hotplates of the cooker are recessed in the hob so that effective boiling facilities are provided for a maximum number of saucepans. Two of the hot plates are 7 inches (17·8 cm) diameter Superspeed radiant plates with simmer switch control, each with a loading of 2 100 W. The third plate is a new solid cast iron 5¾ inches (14·6 cm) diameter boiling plate loaded at 1 000 W and is expected to appeal particularly to housewives who like a solid plate for scone making. An alternative model has four Superspeed radiant plates.

The eye-level grill measures 10½ inches (26·7 cm) by 8 inches (20·3 cm) and has a loading of 1 750 W controlled by a three-heat rotary switch. It accommodates a vitreous enamel grill pan at two levels. The grill pan grid is reversible and allows further adjustment, so that there are altogether six grilling positions.

The thermostatically-controlled oven has a cooking area 14⅜ inches wide, 14¾ inches deep and is 15 inches high (36·5 by 37·4 by 38·2 cm). Even heating is provided by sheathed wire elements mounted behind side panels which are removable for easy oven cleaning. Total loading of the oven is 2 600 W. A neon pilot light indicates when the oven is switched on. On the D765 model an oven timer is provided.

A roomy drawer for warming plates and dishes, 15⅞ inches wide, 19¾ inches deep and 7 inches high (40·3 by 50·2 by 17·8 cm) and heated by a 485 W sheathed wire element is mounted immediately below the oven.

The cooker is finished in white or honeysuckle colour vitreous-enamel and measures overall: 36 inches (91 cm) high to the top of the hob, 54¼ inches (137 cm) to the top of the splash guard, 21¼ inches wide by 22½ inches deep (54·2 by 57 cm). Total loading of the cooker is 10 035 W and it is available in voltage ranges of 200/210, 220, 230/240, 250 V a c only. (*The General Electric Co Ltd of England*, Magnet House, Kingsway, London, W C 2.)

Refrigerator Developments from Morphy-Richards

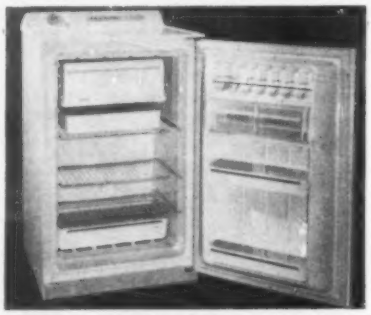
A new Morphy-Richards table-top refrigerator—Model A350—at a very competitive price is announced for the 1961 season.

The square-line cabinet gives a gross storage capacity of 3·5 cubic feet (99 litres) or 3 cubic feet (85 litres) net. It has a vitreous-enamelled working surface with a splash guard at the rear. The door has a magnetic closure and is equipped with an egg rack, a large butter and cheese compartment with perspex sliding doors, and two adjustable shelves for storing jars and milk bottles.

Including the door storage, the A350 has a shelf area of 7·1 square feet (6·6 m²). The cooling unit stores up to 15 lb (6·8 kg) of frozen foods; there are 3 ice trays for making 36 cubes of ice weighing 1·65 lb (748 g). A polystyrene chiller with a lid that can be used as a drip tray, and a large polystyrene drawer for fruit and vegetable storage are also incorporated.

On the standard model the door opens from left to right, but the opposite opening will also be available. Adjustable feet are fitted for levelling the cabinet on an uneven floor.

The compact cabinet occupies less than 2 square feet (0·19 m²) of floor space; it measures 22·4 inches (57 cm) wide, 23·2 inches (59 cm) deep and 35·7 inches (91 cm) high, plus 2·35 inches (5·9 cm) for the splash guard. The exterior finish is either white or cream stove-enamel, with a pale blue interior. The weight is 110 lb (50 kg).



The Morphy-Richards 'Astral' table-top refrigerator

Four versions are available for a c or d c voltage ranges of 95/100, 110/115, 190/220 and 220/250 V. The absorption type unit has a loading of 120 W.

The built-in 1·6 cubic feet (45 litres) refrigerator which Morphy-Richards recently introduced on the British market has now been reduced in price. This model had earlier been launched in the U S A, where it is proving extremely popular for 'on-the-spot' refrigerator needs in homes, and in industry, commerce and medicine.

Three versions of this small, compact model are available for operation on either electricity, town gas or bottled gas—the latter designed especially for caravans, trailers, boats, country cottages and seaside chalets. (*Morphy-Richards (Astral) Ltd*, 50 Conduit Street, London, W 1)

The portable free-standing model of the Panorama infra-red heater

A New-style Infra-red Heater

The recently-introduced Panorama infra-red heater differs from others on the market in that it has a convex reflector and curved elements, and its makers claim that because of this construction it radiates warmth over an arc of nearly 180°.

The convex reflector is of highly-polished aluminium and the two curved silicon-sheathed elements are each 20 inches (51 cm) long—a length which spreads the heat produced over a wide area and minimises the risk of accidental scorching. A plated wire guard is fitted and has quick-release clips for easy removal for cleaning. The body of the heater is of steel and the finish is in hammered grey-beige.

Each of the two elements has a loading of 1 kW, and they can be run together or one can be cut out by a built-in switch. Size is approximately 15 inches (38 cm) high and 25 inches (64 cm) wide, and the weight is approximately 10 lb (4·5 kg). Models are available for voltage ratings of 200/220 or 230/250 V a c.

The Panorama heater is produced in two versions: as a portable free-standing model with a carrying handle, or as a wall-mounted model. In the latter the built-in switch is cord-operated. (*Thermair Domestic Appliances Ltd*, Izons Lane, West Bromwich, Staffs.)

Repeater Switch for use with 11 kV Fuse-Switches

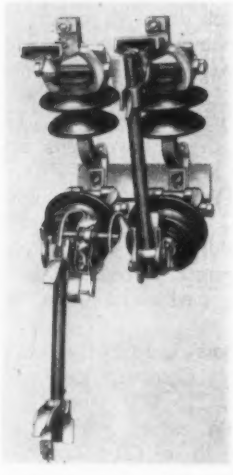
It was announced last year by Johnson & Phillips Ltd that their type 'D' expulsion fuse-switch had been uprated to 11 kV, 150 MVA. Certificates have been issued by

the CESI Laboratories in Milan in accordance with BS 2692 : 1956 covering operations at all current values up to 8 000 A at 11 kV.

Johnson & Phillips have now introduced a repeater unit for use with the new fuse-switches which has been fully tested for the same ratings.

The type 'D' repeater is designed to provide automatic restoration of overhead line supplies after momentary faults have cleared by bringing a second expulsion fuse-switch into the circuit in the event of the first fuse being blown.

The majority of faults which occur on overhead lines are of a transient nature. The resulting power arc established by the flow of fault current usually destroys the cause of the fault, while the arc is in turn extinguished by the opening of the fuse-switch. By the use of a repeater the circuit can be restored automatically through the second fuse.



The Johnson & Phillips type D repeater switch in the open position

The repeater unit consists of a self-aligning contact bar carried at the end of a spring-actuated operating arm. This arm is held in the open position by a release catch and depends on the weight and force of the falling fuse-carrier to cause it to close. When a fault occurs the fuse-carrier of the first fuse-switch, in falling down to its open position, strikes the release catch of the repeater operating arm, thereby permitting the contact bar to be thrust upwards and bridge the horn contacts of the two fuse-switches. The supply is thereby restored through the second fuse-switch. If the fault is not cleared the circuit will again be opened by the second fuse-switch.

To reset the combination in its original condition, the only action required after replacing the blown fuses is to close the first fuse-switch by means of the operating pole, and with the same pole to open the repeater unit by pulling down the operating arm until it is held by the release catch.

Three sets, each comprising a repeater and two fuse-switches, are required on 3-phase systems; for single-phase systems two sets are usually required. To reclose the circuit more than once, two reclosures can be provided by using three fuse-switches per phase, or three reclosures by using four per phase.

The use of the repeater not only reduces the inconvenience to consumers by giving them immediate restoration of supply without waiting for a linesman to visit the site and renew the fuse, but also eliminates much of the linesman's emergency work. The affected fuses can be renewed later during normal inspection tours.

The new repeater unit for use with the type 'D' fuse-switches was thoroughly tested at the CESI Laboratories using a single-phase circuit with a full 11 kV line-to-line recovery voltage.

BS 2692 : 1956 for expulsion fuse switches does not cover repeater units, but the testing proved conclusively during service that the type 'D' fuse-switch fitted with a repeater unit is capable of meeting the requirements set out in the Standard, *i e* of satisfactorily operating under fault conditions not exceeding rated capacity without dangerous scattering of hot metal or other substances and without breakdown or significant electrical leakage to earth or between poles, nor damage to associated equipment.

After operation, the mechanical parts and supporting isolators were essentially in the same condition as before the test, and after renewal of the element the fuse-switch and the repeater were capable of carrying the rated current at rated voltage and operating at a fusing current up to breaking capacity rating. (*Johnson & Phillips Ltd*, Charlton, London, S E 7.)

A Miniature Temperature Recorder

The Cambridge Minican temperature recorder is so small that it can be used in a variety of unusual conditions, typical examples being in cooking vessels of all sizes; on lorries hauling perishable goods; in sterilising processes. According to its makers, one of its outstanding applications is in the canning and brewing industries, where the bulb may be sealed in a tin or bottle and the complete instrument passed along a conveyor belt, providing a continuous record of the process temperatures.

The instrument consists of a chart (40 mm wide) mounted on a drum which revolves at a constant rate, permitting a pen to trace a temperature record for 2 hours, 12 hours or 24 hours. The pen is moved by the expansion and contraction of the liquid in the stainless steel bulb, which may be either plain or spiral-shaped. The drum is operated by a built-in mechanical clock which runs for one of the three fixed periods mentioned above.

In use, both chart and pen are completely enclosed in a chromium plated brass cylinder which is liquid and gas proof and is capable of standing up to high cooking pressures, so that the complete instrument may be enclosed in ovens or cold stores.

The minimum temperature range is 50 deg across the chart, giving for example 120 to 170 deg F (48·9 to 76·7 deg C), 240 to 290 deg F (115·6 to 143·3 deg C), —30 to +20 deg C (—22 to +68 deg F) or 110 to 160 deg C (230 to 320 deg F), and an accuracy of 0·5 mm (0·02 in) on the chart width is to be expected.

Dimensions are 4½ in plus 2 in bulb (11·4 plus 5·1 cm) high and 2¾ in (6·9 cm) diameter; its weight is 1·5 lb (0·68 kg). Each instrument is supplied with a packet of 100 charts and a 1 oz (28 g) bottle of special ink. (*Cambridge Instrument Co Ltd*, 13 Grosvenor Place, London, S W 1)

A 'Packaged' Switching Station

A new outdoor 'packaged' switching station is being produced by English Electric. Called the 'Weatherbeater', this completely self-contained 33 kV unit occupies little more space than a conventional indoor installation and much less than a normal outdoor station.

Associated civil engineering costs are low, as the unit needs only a simple concrete raft foundation. No building is necessary. The exterior weatherproof housing is of aluminium, which needs no painting or periodic maintenance.

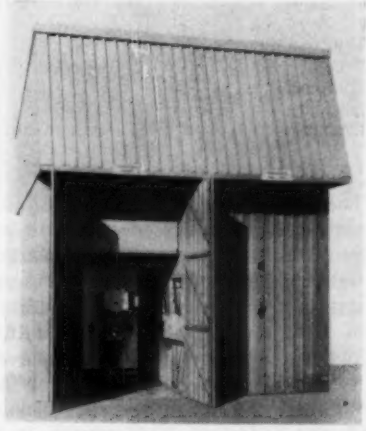
A switching station is built from standard units, each 16 ft 9 in (5·1 m) high by 12 ft 3 in (3·7 m) deep. A 1 200 A unit is 6 ft 6 in (2 m) wide and a 1 600 to 2 000 A unit is 7 ft 3 in (2·2 m) wide.

Each unit houses either an English Electric OKM4 or OKM5 single-tank oil circuit-breaker for current ratings up to 1 200 A and 2 000 A respectively. It is available in single busbar form for short-circuit ratings of 750 and 1 000 MVA.

Isolation is by means of hand-operated isolators on both sides of the circuit-breaker. Built-in cable and (where required) busbar earthing equipment are included, as well as hand-operated safety shutters.

All the usual interlocks associated with metal-clad gear are provided. The isolators, earthing equipment and shutters are all operated from a single control point mounted on the side of each unit. Operation is simple and quick and the mechanical interlocking ensures that the correct sequence is always followed.

A model of the 'Weatherbeater' will be shown at the ASEE Exhibition in London from March 21 to 25, 1961. (*The English Electric Co Ltd*, English Electric House, Strand, London, W C 2.)



An English Electric 'Weather-beater' switching station housing two 33 kV feeder units

A Review of the Nuclear Power Programme

FIRST TWO NEW STATIONS NEARING COMPLETION

WITH the prospect of the first reactor at each of two of Britain's newest nuclear power stations coming into operation in the summer of this year, this is an opportune moment to review the progress and present position of the nuclear power programme in the United Kingdom.

Following the successful operation of Calder Hall—the first nuclear station in the world to generate power on a commercial scale—commissioned and formally opened by H M Queen Elizabeth II in October, 1956, the Government issued in February, 1955, a White Paper outlining a provisional programme for building in the ensuing ten years nuclear power stations with a total generating capacity of some 1 500 to 2 000 MW.

In 1957 it was announced that the nuclear programme was to be increased to 5 000 to 6 000 MW by 1965. However, because of capital cuts imposed on industry by the Government, together with changes in the fuel supply position and in relative costs, the programme was again revised in 1960 and now provides for 5 000 MW of nuclear plant capacity by 1968.

At the present moment, a total of eight nuclear power stations are in various stages of near-completion, construction, or in preparation. Seven of these are for the Central Electricity Generating Board, and one for the South of Scotland Electricity Board. Details are as follows.

Station	Commissioning of First Reactor	Output Capacity (approx.) MW
Bradwell	1961	300
Berkeley	1961	275
Hinkley Point	1962	500
Hunterston (Scotland)	1962/63	320
Trawsfynydd	1963	500
Dungeness	1964	550
Sizewell	1965	580
Oldbury	Not yet announced	550

Nuclear Power Programmes

The technical requirements of sites for nuclear stations may change as new designs are evolved but for the first stations they are, primarily, large volumes of cooling water and sub-strata which can support the very heavy station structure and plant. In addition, the White Paper of 1955 stated that the early stations would be sited away from large towns and in sparsely populated areas.

Construction of the first two nuclear stations—at Bradwell in Essex, and Berkeley in Gloucestershire, started in January 1957.

Each of these first two stations has two natural uranium, carbon dioxide gas-cooled, graphite-moderated reactors—the graphite core of the reactor being contained in a steel pressure vessel 3 in (76 mm) thick. In the initial design stage, the output capacity of each station was expected to be between 100 and 150 MW, but as a result of technical progress, particularly in the technique of welding thick steel plate for the reactor pressure chamber, much larger capacities have become possible.

Unlike the Atomic Energy Authority's plant at Calder Hall, which must be shut down in order to change fuel in the reactor, the plants now under construction for the C E G B have provision for fuel changing while still on load.

The Bradwell station, which is being built by the Nuclear Power Plant Company Ltd, will have a guaranteed net output capacity of 300 MW, provided by six turboalternators each of 52 MW rating, with high-pressure steam conditions of 763 lb/in^2 (53·6 kg/cm^2) at 704 deg F (373 deg C). In addition, approximately 30 MW will be generated in separate turboalternators to supply the motor-driven blowers which circulate the coolant gas.

The Berkeley station, which is being built by the A E I—John Thompson Nuclear Energy Company Ltd, will have a guaranteed net output of 275 MW from four turboalternators each of 83 MW rating, with high-pressure steam conditions of 306 lb/in^2 (21·5 kg/cm^2) at 612 deg F (322 deg C); the blowers in this case will be driven by motors on the main station supply.

Statutory consent for the construction of the Board's third nuclear station, at Hinkley Point, near Bridgwater, Somerset, was given in June, 1957. This station is being built by the English Electric/Babcock & Wilcox/Taylor Woodrow Atomic Power Construction Co Ltd. and will be of a similar type to the first two, with two reactors and a guaranteed net output of 500 MW. It is planned to come into operation in 1962.

An Inland Site

Consent for the Board's fourth nuclear station at Trawsfynydd, Merionethshire—the first in Wales—was received in July, 1958. The site is unusual in that it is situated inland on the shore of the large reservoir specially created for a hydro-electric station. The reservoir is of sufficient size to provide the cooling water required.

The Trawsfynydd station is being built by Atomic Power Construction Ltd, and will have two carbon-dioxide gas-cooled graphite moderated reactors with a total output capacity of 500 MW. It is planned to come into operation in 1964 and will be connected to the 275 kV transmission system at the pumped storage

station now under construction at Ffestiniog, some five miles (8 km) to the north.

Consent for the Board's fifth station at Dungeness in Kent was given in July, 1959, and for the sixth station at Sizewell, on the Suffolk coast, in February, 1960. Construction of Dungeness, by The Nuclear Power Group, began in August, 1960, and it is expected that work will start on Sizewell early in 1961. This station will be built by the English Electric/Babcock & Wilcox/Taylor Woodrow Atomic Power Construction Co Ltd.

Application was made in April, 1959, for consent for a seventh nuclear station at Oldbury on the Severn Estuary, some four miles (6·4 km) downstream from the Berkeley station, and was granted in October of the same year.

Nuclear generation will, in the first instance, be used principally to assist in supplying the growing needs of consumers in areas where there is insufficient locally-produced coal for electricity generation purposes. Coal-fired generation will in the main continue to be developed in and near the coal-fields.

Some two-fifths of the total electrical demand in England and Wales lie south of a line from Bristol Channel to the Wash, and in this wide area nuclear generation must play a prominent part. Wherever the nuclear stations are situated, high voltage overhead transmission lines will be needed to link them to the grid and supergrid systems.

The capital costs for the first two nuclear stations are in the region of £160 per kilowatt of output capacity and for the third station about £133 per kilowatt, with a further £30 per kilowatt for the capital cost of the initial nuclear fuel charge. This compares with about £45 per kilowatt for the most modern and efficient conventional steam station to be completed about the same time. However, the capital cost per kilowatt of future nuclear plant should tend to fall with time and thus reduce total generation cost.

Bradwell

The nuclear power station at Bradwell-on-Sea, Essex, is located on the south-east extremity of the estuary of the Blackwater river.

The plant consists of two natural uranium carbon dioxide gas-cooled graphite moderated reactors, supplying heat to twelve boiler units. Six boilers are associated with each reactor, and are placed in two groups of three on opposite sides of the reactor to form one complete unit. There are six turboalternators each of 52 MW capacity.

Each reactor core comprises a vertical cylinder approximately 45 feet (13·7 m) in diameter by 31 feet (9·4 m) high, built up from graphite blocks and containing about 2 600 fuel channels. The core is contained in a spherical steel reactor pressure vessel which, in turn, is surrounded by a concrete biological shield about 8 feet (2·4 m) thick.

The uranium fuel elements are uranium rods, approximately 1 inch (25·4 mm) in diameter and sheathed in magnesium alloy. Carbon-dioxide gas at a pressure of 130 lb/in^2 (9·14 kg/cm^2) transfers the heat produced in each reactor to its six associated boiler units, via 5 feet (1·5 m) diameter ducts. Six blowers, each connected to the outlet of a boiler, circulate the gas back into the bottom of the reactor vessel.

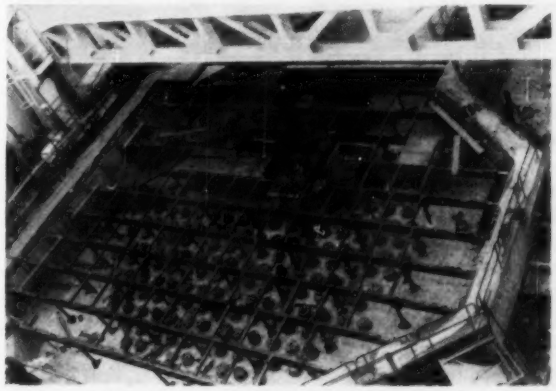
Three 20 MW turboalternators (a total of 90 000 h p) are used for supplying power to these blowers.

The reactors will be re-fuelled on load, the fuel channels being replenished progressively—a few at a time.

For condensing purposes, 21 million gallons (95 million l) of cooling water an hour will be required and this will be drawn from the Blackwater estuary and pumped through concrete culverts to the condensers and thence discharged back to the estuary.

The pressure vessel containing the reactor core is a sphere 66 feet 9 inches (20·3 m) in diameter and is fabricated on site from 3 inch (7·6 cm) thick steel plates. The plates are pressed and cut to size at the manufacturer's works and then delivered to site where they are welded in the site workshops by automatic welding machines into four-plate sections. These are then assembled to form horizontal rings and hand-welded together. These ring sections are then transferred to within the biological shield of the reactor building by a Goliath crane which is capable of lifting 200 ton (203 200 kg) loads and which completely spans the reactor building. The ring sections are manually welded inside the shield to form the complete sphere.

The boilers are cylindrical pressure vessels 92 feet (28 m) high and 19 feet (5·8 m) in diameter, which are constructed complete at the manufacturer's works and then towed down to the site by sea. When landed at Bradwell they are lifted into position around the reactor by the Goliath crane, after which internal tubing is undertaken. Each boiler will produce approximately 250 000 lb (113 000 kg) of steam an hour to the turbine at two pressures—763 lb/in^2 and 199 lb/in^2 (53·6 kg/cm^2 and 14 kg/cm^2) at a temperature of 704 deg F (373 deg C).



A view of No 1 reactor pile cap at Bradwell, showing the girder work for the installation of the cover plates. The beam at the top of the picture is part of the charge/discharge machine gantry

The main turbines are double admission twin cylinder machines with a double exhaust to twin condensers. Included in the main steam system are two dump condensers capable of dealing with approximately 10 per cent of the load output to the reactors. The main generators are hydrogen-cooled and each of 52 MW

capacity at 3 000 rev/min and their output voltage is 11·8 kV. Direct-connected transformers step this voltage up to 132 kV. The main switchgear is of an air-blast type with a rupturing capacity of 3 500 MVA at 132 kV located in an outdoor switch station adjacent to the station site.

The control of the station is from a central control room which contains the controls for the reactors and boilers, turboalternators and electrical switching operations. From this point it will be possible to monitor the whole of the plant and effect essential operations.

Berkeley

The nuclear power station at Berkeley, Gloucestershire, lies on the eastern bank of the Severn Estuary roughly midway between Gloucester and Bristol.

The station, when completed, will have an output of 275 MW, or over 360 000 h p. The plant consists of two natural uranium, carbon dioxide gas-cooled, graphite moderated reactors, supplying heat to 16 boiler units. Eight boilers are associated with each reactor and are grouped round it to form one complete unit. There are four dual-pressure turbogenerators, each of 83 MW capacity.

Each reactor core comprises a vertical cylinder approximately 48 feet (14·6 m) in diameter by 30 feet (9·1 m) high, built up from graphite blocks and containing 3 250 vertical fuel channels. The core is contained in a cylindrical steel pressure vessel 3 inches (76 mm) thick, which, in turn, is surrounded by a concrete biological shield having a thickness of 8·5 feet (2·59 m).

The fuel elements are uranium rods, approximately 1 inch (25·4 mm) in diameter and sheathed in magnesium alloy. Carbon dioxide gas at a pressure of 125 lb/in^2 (8·79 kg/cm^2) transfers the heat produced in each reactor to its eight associated boiler units through 5 feet (1·52 m) diameter ducts. Eight blowers, each connected to the outlet of a boiler, circulate the gas back into the reactor vessel.

As at Bradwell, the reactors will be re-fuelled on load, the fuel channels being replenished progressively—a few at a time.

For condensing purposes, 21 million gallons (95 million litres) of cooling water per hour will be required. This will be drawn from the River Severn 650 feet (198 m) off-shore and discharged back into the river through four near-shore outlet culverts, one serving each turboalternator. A baffle wall has been constructed in the estuary to prevent recirculation of the cooling water.

Accuracy for Welding

The pressure vessel containing the reactor core is cylindrical with domed ends, 80 feet (24·4 m) high and 50 feet (15·2 m) in diameter, and is fabricated on site from 3 inch (7·6 cm) thick steel plates. Most of the plates are lifted singly into position. Some prefabrication of the smaller plates is carried out, but the heaviest single lift is 15 tons (15 240 kg).

To facilitate welding on site it was necessary for all plates, pressed and cut to size in the manufacturer's works, to be accurate to one-sixteenth of an inch (1·5875 mm), and to maintain this accuracy templates were employed. These templates, which were of sheet steel, were in turn accurate to one sixty-fourth of an inch (0·3969 mm).

After pressing to shape, the plates were edge-prepared for welding by a special flame planing technique. This process leaves the correct weld preparation angles on the curved edges of the plates without need of machining or further work.

The boilers or heat-exchangers are cylindrical pressure vessels 70 feet (21·3 m) high and 17·5 feet (5·3 m) in diameter. They are fabricated from steel plate made up of five cylindrical sections forming the body of the vessel and a domed section at top and bottom. Each of the seven sections is completed as far as possible at the manufacturer's works and transported to the site for assembly. The whole of the welding must be to Class 1 requirements and the complete vessel must be stress-relieved and hydraulically tested after welding. Each cylindrical body section is made from two curved steel plates, $1\frac{1}{8}$ inches (28·6 mm) thick, roll-formed cold to shape and machine welded to form a complete ring.

Each boiler will produce approximately 200 000 lb (90 700 kg) of steam an hour at two pressures—306 lb/in^2 and 62 lb/in^2 (21·5 and 4·36 kg/cm^2) at a temperature of 612 deg F (322 deg C).

The four turboalternators are 3 000 rev/min machines designed to accept steam at the two pressures generated by the boilers. They have triple exhausts designed for a back pressure of 0·4416 lb/in^2 (31·0 g/cm^2). The alternators are hydrogen-cooled and generate at 11·8 kV.

The control of the station is from a central control room which contains the controls for the reactors and boilers, turbogenerators and electrical switching operations.

Hinkley Point

Hinkley Point is situated on the north coast of Somerset, about 11 miles (18 km) to the east of Minehead and 10 miles (16 km) north-west of Bridgewater.

It will have a net output of 500 MW, the plant consisting of two natural uranium, carbon-dioxide gas-cooled reactors, supplying heat to twelve boilers. Six boilers are associated with each reactor, and are placed in two groups of three on opposite sides of each reactor to form a complete unit. Total steam production will be approximately 5·5 million pounds (2·5 million kg) of steam an hour, and this will supply six main turbogenerators, each of 93·5 MW maximum rating, and three variable speed turbogenerators which will provide power for the gas circulator drives. Each complete reactor building is 180 feet (54·9 m) high, 345 feet (105 m) long and 185 feet (56 m) wide.

The turbine house situated on the north side of the reactors is 704 feet (214 m) long, 231 feet (70 m) wide including annexes, and 62 feet (19 m) above ground level with a 30 feet (9·1 m) deep basement. The main control room is adjacent to this building on the south side. At the east end of the turbine house are the workshops, stores, and administration buildings.

For condensing purposes, 35 million gallons (159 million l) of water an hour will be required, and this will be drawn from the Bristol Channel and pumped

through concrete culverts to the condensers, and thence discharged back to the Channel.

The intake system has been designed to supply a possible second station adjoining the present one, with probable water requirements of 50 million gallons (227 million l) an hour.

A feature of the design of the circulating water system is that it had to take into account a rise and fall in the tide in excess of 40 feet (12 m).

Reactors and Boilers

Each reactor core will comprise a vertical 24-sided polygon 25 feet (7·6 m) high and 49 feet (15 m) in diameter, built up from graphite blocks and containing 4 500 fuel channels. This core will be contained in a spherical steel reactor pressure vessel, which in turn is surrounded by a concrete biological shield about 9 feet (2·7 m) thick.

The uranium fuel elements will be uranium rods, just over 1 inch (25·4 mm) in diameter, and sheathed in magnesium alloy. Carbon-dioxide gas at a pressure of 185 lb/in^2 (13 kg/cm^2) will transfer the heat produced in each reactor to its six associated boiler units via 6·5 feet (2 m) diameter ducts. Six blowers driven by a c motors, each connected to the outlet of a boiler, will circulate the gas back into the bottom of the reactor vessel. Three 33 MW capacity, variable frequency auxiliary turbogenerators, one acting as stand-by, are to be used for supplying power to these blowers.

The reactors will be refuelled on load, the fuel channels being replenished progressively, a few at a time, by charge/discharge machines operating on the pile cap.

The pressure vessel containing the reactor core is a sphere of 67 feet (20 m) in diameter and is fabricated on site from 3 inch (7·6 cm) thick steel plates. The plates are pressed, cut to size and, in some cases welded in pairs at the manufacturer's works and delivered to site where they are hand-welded in the site workshops. These ring sections are transferred to the biological shield of the reactor building by a Goliath crane which spans the reactor buildings and has a span of 250 feet (76 m) and a clear height of 210 feet (64 m) and which is able to lift 400 ton (406 400 kg) loads by means of two grabs. The ring sections are manually welded together inside the shield to form the complete sphere.

The vessel is supported by an external cylindrical skirt having a diameter of 30 feet (9·1 m). A similar internal skirt supports the diagrid, which supports the weight of the core.

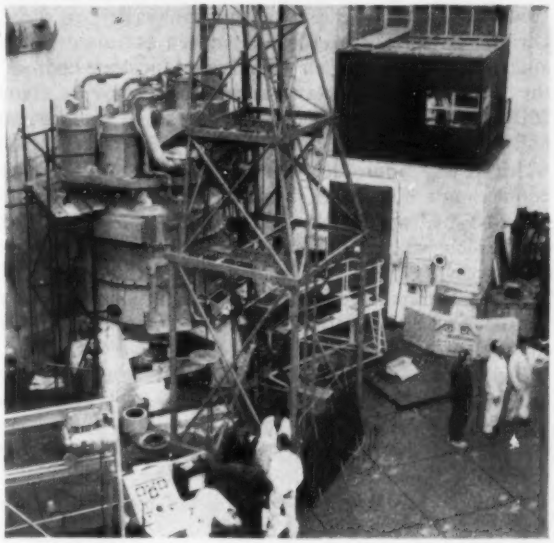
The boilers are cylindrical structures 90 feet (27 m) high and 21·5 feet (6·6 m) in diameter with a wall thickness of $2\frac{3}{8}$ inches (6 cm). The ring sections of the shells are fabricated with all connections at the manufacturer's works and then stress-relieved. They are welded together to form the complete vessel and lifted into position by the 400 ton Goliath crane. Each boiler will produce approximately 483 000 lb (219 000 kg) of steam an hour at two pressures: 660 lb/in^2 (46·4 kg/cm^2) at a temperature of 686 deg F (363 deg C) and 183 lb/in^2 (12·9 kg/cm^2) at a temperature of 670 deg F (354 deg C).

Turbogenerators

The main turbines are three cylinder in-line machines with double admission. The high-pressure cylinder exhausts into the two low-pressure cylinders which are both of the double flow type, each one having its own condenser.

Included in the main steam system are two dump condensers each capable of about 10 per cent of the output of one reactor, or 5 per cent of the total station steam output.

The main generators are hydrogen-cooled and designed for a normal output of 87 MW each with hydrogen at 15 lb/in^2 (1·05 kg/cm^2). By raising the hydrogen pressure to 25 lb/in^2 (1·76 kg/cm^2) it is possible to load the generators to the maximum output of 93·5 MW. The generation voltage is 13·8 kV and generator transformers step this up to 275 kV for transmission. The main switchgear is located in an outdoor switch station on the landward side of the reactor buildings, and is of the air-blast type with a rupturing capacity of 7 500 MVA at 275 kV.



The charge face area and the charge machine of No 1 reactor at Berkeley

Fuel Handling and Control

The charge building houses the equipment for receiving, sorting, inspection, storage and general handling of unirradiated fuel, sub change rooms, shield cooling fans, CO_2 make-up supply, reactor switchgear, control rod power supplies, burst fuel element detection and flux measuring equipment. The discharge building houses the equipment for removing the irradiated fuel after removal from the reactor core to the irradiated fuel storage ponds and the testing facilities for fuelling and hole preparation machines.

Fuelling machines and hole preparation machines operate on the pile cap which is provided with an overhead gantry crane of 155 tons capacity, and local workshop facilities.

A cooling pond and handling equipment are provided for each reactor in which irradiated fuel discharged from reactors can be stored for several months to allow the high intensity radiation to die down before it is transported to the United Kingdom Atomic Energy Authority's chemical factory for processing.

Control of the stations will be from a central control room where the main switchgear controls, main running controls for blower speed, control rod position, turbine throttle setting and all important indicating, recording and alarm instrumentation will be located. Starting and supervision of plant is to be carried out locally.

Progress at Hunterston

The major portion of the civil engineering work on the two reactor structures and the turbine hall of the Hunterston station has now been completed. The station, which is situated on the Ayrshire coast, some 35 miles (56 km) south-west of Glasgow, is being built for the South of Scotland Electricity Board by the G E C–Simon Carves Atomic Energy Group.

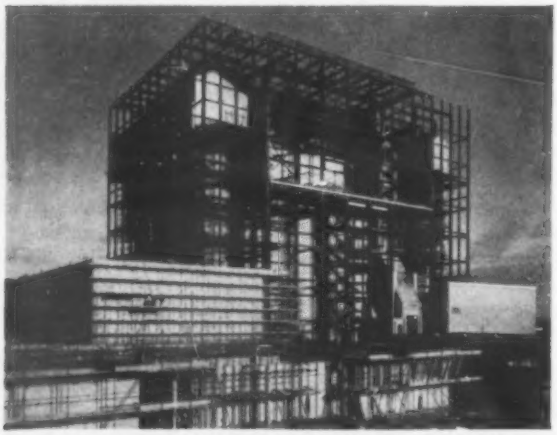
It occupies approximately 160 acres, including the foreshore and access road, but the site of the station itself extends to about 90 acres, comprising arable land adjacent to a gently shelving boulder-strewn shore. On the geological map the site is given as 'raised beach' and comprises boulder clay overlying sandstone bedrock, the thickness of the clay varying from zero to about 20 feet. The station will have two reactors. The turbine hall will be approximately 700 feet long and 130 feet wide; it will house six 60 MW turbogenerators each comprising a dual pressure turbine driving an alternator cooled by hydrogen at a pressure of 30lb/sq in (2kg/cm^2).

The mean diameter of the reactor vessels will be 70 feet and they will have a working pressure of 150 lb/in^2 (10·5 kg/cm^2) The number of fuel channels in the reactor core will be 3 288 and the total reactor heat output will be in the region of 535 MW.

Inside the first reactor structure, the assembly of the 3 inch (76·2 mm) thick, 70 feet (21·34 m) diameter pressure vessel is complete, all courses having been placed and welded together, with the core support grid and inner heat shield located inside the vessel.

The supporting skirt of the second reactor pressure vessel has been fabricated *in situ* inside the biological shield and the combined bottom head and support course, No 2 course and the core support grid have been lifted into position.

Elsewhere on the site fabrication and assembly of the steam-raising units has been going ahead; several of the 210 ton (213 370 kg) vessels, having been stress-relieved and hydraulically tested, are now in the final stages of construction, which includes nuclear clean conditioning. The first steam-raising unit associated with the first reactor was accepted and lifted by the Goliath crane on to its plinth in September, 1960. Since then three more steam-raising units have been placed in position.



The No 1 reactor building at Hinkley Point. All the 12 heat exchangers for both reactors are in position and construction of the pile cap roofs is in progress

Externally, the 680 feet (208 m) long turbine hall appears complete, although internally much work is in progress. Four of the six condensers are being installed, the first having recently been completed, while the foundations for the turbo-generators are ready, awaiting the arrival of the sets themselves.

Reactor A

On the north and south sides of the now-completed concrete biological shield, the adjoining 'reactor building' and 'exit building' are being constructed. On the other two faces of the biological shield the eight concrete plinths and their connecting floors are ready for the steam-raising units, four of which are already in position. All the seal oil pumps, tanks and coolers have been installed at the various levels in the reactor structure.

Much of the concrete structure upon which the tracks of the service machine will be mounted has been built and some of the associated steelwork is being erected. The 150 ton (152 000 kg) machine will be situated at the 178·5 feet (54·5 m) level, above the biological shield roof of the reactor, and will have longitudinal and cross-traverse facilities.

A rehearsal shaft for the charge-machine is included in the reactor structure and the civil engineering for this is finished. It will be able to test every function of the charge machine and is expected to be used daily when the station is in operation.

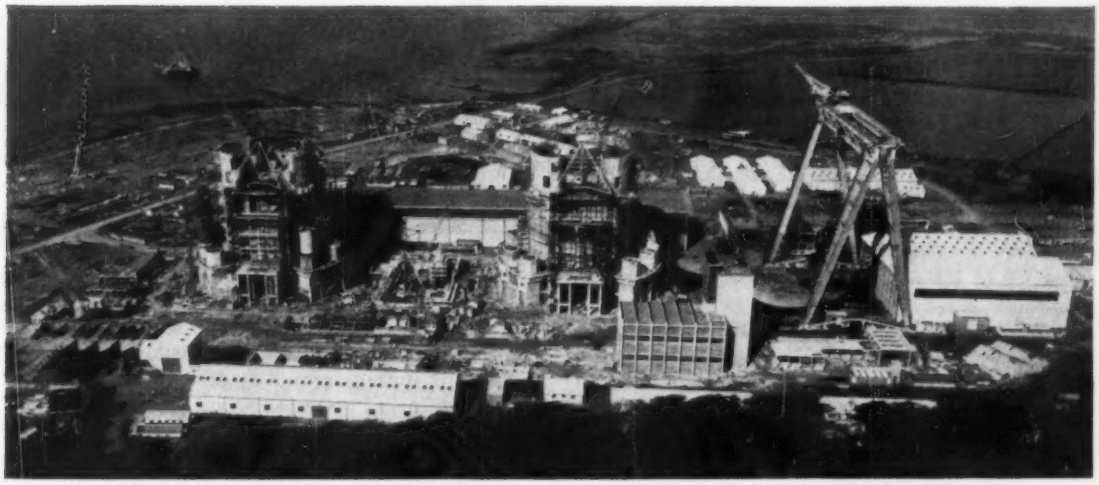
The top inner surface of the pressure vessel is to be cooled by diverting some of the incoming CO_2 coolant gas through a system of pipes suspended between the inner heat shield and the pressure vessel dome. These pipes, which are perforated on the upper surfaces to permit the escape of the coolant gas, have now been erected.

Closing in of the reactor structure with precast concrete units, which form the soffit of the roof biological shield, has begun. Six inverted double-webbed T-beams are being used for this purpose and they span the aperture, being supported at each end on a 308 ton (312 900 kg) member.

During the past few months the first gas circulator drive has been undergoing a test of continuous running under load conditions and under simulated conditions of misalignment. Each gas circulator will be situated in the base of a steam-raising unit so that it will handle gas at the lowest temperature. The circulator will be mounted vertically, with the impeller and diffuser inside the shell and the drive outside. This simplifies the gas sealing arrangements.

Reactor B

As indicated earlier, the concreting of the 9 feet (2·74 m) thick biological shield has reached an advanced state of completion.



An aerial view of Hunterston. The first steam-raising unit of reactor A can be seen on its plinth

Four steam-raising unit shells have been internally cleaned and are in position on their plinths, ready for the erection of the main gas ducts and installation of the internal tube banks. The shells of the other 11 steam-raising units, for both reactors, are in the process of assembly.

The construction of the circulating water works is probably the most advanced on the station. The intake headwork and jetty and the lining of the twin intake tunnels and land shafts are finished: this is also true of the main structure of the pumphouse, including the outer stonework facings.

The penstocks and all eight bandscreens inside the pumphouse have now been erected, together with all six main circulating-water pumps, their 800 h p motors and associated pipework and valves.

To prevent fouling of the various culverts and pipework by marine organisms, the circulating-water system is provided with equipment which delivers chlorine solution to the intake headworks.

The civil engineering on the interior of the turbine hall is substantially complete. All the concrete foundation blocks for the six turbogenerators have been laid and work on the foundations steelwork for four of the sets is proceeding. Two 440 kW alternator exciters are being stored in the building.

The first main condenser is installed, and the second and third are in an advanced stage of erection. Good progress is reported on the erection of the first set of feed-heating plant and extraction pumps.

The hydrogen water/water coolers on the north side of the first turbogenerator blocks have now been assembled in position and the copperwork between the first two blocks erected as far as possible.

Under the control room the Mulsifyre-system diesel pumps are installed, together with the refrigerating plant, ductwork, and fans for the central control room air-conditioning system.

The h p and l p steam receivers have been placed in position and fitted with their valves; in addition, the pipe supports for the steam and feed ranges have been grouted in under the operating floor, and over half of the pipework for the first part of the contract has already been erected. Near the centre of the south annexe, both dump condensers with their desuperheaters are now being erected.

The workshop to the east of the turbine hall is nearly complete so far as cladding is concerned, and the crane is already installed.

The charge-machine maintenance building, to the south of reactor B, is linked to both reactor structures by means of rail tracks. These serve to bring the charge machines, which are at ground level, into the building for servicing.

The building is practically finished, an interesting feature being the inclusion of a clean-conditions tower, a necessary adjunct when carrying out maintenance on the interior of the charge machine. A 45 ton (45 700 kg) crane is installed in the tower for lifting the top off the machine, together with a 25 ton (25 400 kg) crane in the main hall area.

The walls of this building have been constructed from specially-fabricated concrete slabs erected inside the main framework so as to present a completely smooth surface for ease of decontamination if necessary.

The building will also be equipped with a rehearsal shaft and a complete set of control equipment.

Between the reactors, in the space used initially for prefabricating concrete floor sections, the cartridge cooling pond has been re-excavated and a start has been made on the construction of the active-solid-waste building.

The active-waste disposal plant, on the south side of the two reactors, consists of the treatment house, delay tanks, and cartridge cooling pond sludge tanks. The delay-tank walls and protective brickwork, and the associated pumphouse are well on the way to completion.

The 'Silavent' System of Sanitary Ventilation

MEDICAL authorities have long known that the use of the water-closet plays an important part in the spread of infectious diseases, and the continuance of a spread of infection even in cases where strict personal hygiene was practised led to a suspicion that airborne transmission was a possibility.

This suspicion is now proved to have been justified by recent research work which strikingly demonstrated that the flushing of a water-closet generates particles of sizes capable of penetrating to the lower respiratory tract, as well as deposition in the nose, mouth and eyes, and upon surfaces touched by the hands.

It was known that the flushing of a toilet produces a bacterial aerosol because of the fact that whenever a liquid is mixed with air in violent agitation, minute droplets of the liquid become airborne. These rapidly evaporate, but when the liquid contains foreign matter, the remaining minute particles float in the air.

The neat and unobtrusive Silavent installation is well shown in this photograph. The externally-mounted extractor fan is shown in the small inset photograph on the left

Experiments have confirmed that the bacterial aerosol can remain airborne for considerable periods after flushing, and may be a more dangerous source of potential infection than that created by the handling of contaminated surfaces. Closing the lid of a water-closet reduces to some degree the escape of the aerosol into the room, but it is by no means a reasonable safety measure. A bacterial aerosol can also be produced by a second flushing.

Various types of bacteria and viruses have been found in soiled lavatory bowls, and in a paper published in *The Lancet* recently it was pointed out that it is not unreasonable to expect also to find causal agents for diseases such as tuberculosis and poliomyelitis.

To counter any possibility of airborne infection from this source, Morphy-Richards (Installations) Ltd have developed a special unobtrusive ventilating device—known as Silavent—which extracts the aerosol and polluted air direct from the water-closet bowl and discharges them harmlessly into the atmosphere. It is claimed to be the only device on the market which can completely eliminate the escape of areosols and polluted air into the room.

This Silavent system, which is covered by world patents, comprises a moulded plastic seat and cover of standard appearance and made to B S 1254 : 1945, with the addition of a special hollow collector fitting unobtrusively into the seat hinge. The intake opening is on the underside where it is out of sight and free from accidental soiling, and it gives a balanced intake action which eliminates draughts, so allowing the system to operate unnoticed.

From the collector unit runs a length of polythene tubing terminating in an extractor fan mounted on the outside of an external wall. The weatherproof fan unit incorporates an automatic draught shut-off to prevent the ingress of cold air or dust when the unit is not in operation.

The Silavent system can be operated by a normal ceiling switch connected to the fan, or it can be operated automatically by coupling to a door-operated switch. It cannot cause radio or television interference.

Universal Application

The Silavent may be fitted practically anywhere when the toilet is within reach of an outside wall. Installation is simple, the only structural work involved being the drilling or cutting of a hole in an outside wall. It is equally suitable for new or old buildings, homes, offices, hotels, factories and similar applications. With the exception of a very few special type close-coupled suites, the Silavent seat will fit nearly all w c bowls, new or old.

In multiple installations such as schools, factories, public lavatories and so on, Silavent seats are available with alternative collectors suitable for use with ducted ventilation systems operating at lower pressures than the standard Silavent fan. These may also be used in conjunction with mechanical ventilation systems already in use in high buildings in cities where outside wall space is not available for toilet location.

Confined spaces always greatly accentuate the problem of polluted air, and the use of the Silavent system in ships' toilets contributes enormously to the maintenance of cleaner air conditions, especially below decks. The use of alternative low-pressure collectors with standard Silavent seats is well suited to permit direct connection to the normal exhaust ducting of the vessel.

One of the first major orders for Silavent was for the new 45 000 ton P & O Orient passenger liner *Canberra*, where all the 812 lavatories for the passengers and crew are fitted with low-pressure Silavent fittings connected to the exhaust ventilation trunking.

Book Reviews

Electricity Undertakings of the World. 1960-61. $8\frac{3}{4} \times 6\frac{3}{8}$ *in* (222 × 162 *mm*). *Pp* 650. (*Benn Bros. Ltd, London* 1960.) Price 35s 6d net.

This well-known reference work, now in its 70th edition, has been revised and extended to make it even more useful than the previous editions. Details are given of the reorganisation of the Central Electricity Generating Board covering the new administrative regions; also included is some new information on the arrangements made for merging Districts of the South-Western Board. The British Commonwealth section now contains new details concerning the electricity supply in the Solomon Islands, Somaliland, Pakistan, and Pemba Island in East Africa. In the Foreign Undertakings section, fuller information regarding electricity supply in Moscow and new details of several of the hydro and steam generating stations in the U.S.S.R. are given.

While this work depends on the co-operation of undertakings all over the world, and while the editor of this reference book appeals to those supply authorities who do not submit details to do so in future, nevertheless this publication is unique in providing a wealth of information.

Practical Electrician's Pocket Book—1961. $5\frac{1}{4} \times 4$ *in* (137 × 102 *mm*). *Pp* 530. *Illustrated.* (*Odhams Press Ltd.*) Price 7s 6d net.

This useful pocket-sized book has been considerably improved by the inclusion of several new features. These cover automation, motor maintenance, transformers, automatic oil burners, wireman's tools and accessories.

Several other chapters have been revised and extended, including those on domestic appliance repairs, power factor correction and space heating. This handbook, now in its 63rd year of publication, provides explanations and practical guidance on many aspects of the electrician's work.

With more than 30 chapter headings, electricians and electrical students will find it a convenient handbook of great value.

Garcke's Manual of Electricity Supply. $8\frac{1}{2} \times 6$ *in* (216 × 152 *mm*). *Pp* 816. (*London: Electrical Press Ltd*, 1960.) Price £4 4s net.

First published in 1896, the 57 volumes of 'Garcke's' Manual have always given a comprehensive record of the electricity supply industry and the electrical manufacturing industries in Great Britain. It is with regret that we learn that this is the last edition of a series that has given valuable service to the electricity industry.

As in previous editions, the 57th volume contains information concerning the electricity supply in England, Scotland, Wales and Ireland and it also gives information on all generating plant and future programmes.

The manufacturers' section contains financial and constitutional details of manufacturers' representative bodies. Lastly, there is a list of executive personnel connected with the electricity supply industry.

Much of the usefulness of a work of reference lies in knowing where to turn quickly for the required information, and if only for this quality, *Garcke's Manual of Electricity Supply* will be sadly missed.

F B I Register of British Manufacturers—1961. $9\frac{1}{2} \times 7\frac{1}{2}$ *in* (241 × 191 *mm*). *Pp* 1162. (*Kelly's Directories Ltd and Iliffe & Sons Ltd*, 1961.) Price 50s net.

The F B I Register is a comprehensive and accurate guide to the membership of the Federation of British Industries. It contains an alphabetical list of the products and services of nearly 8 000 member firms of the Federation. The glossaries in French, German and Spanish give translations of every product term used in the main buyers' guide, each being numbered for easy reference.

Trade associations are also listed alphabetically with addresses, by-products and services, each with its own language glossary. Brands, trade names and trade marks used by the members of the Federation are listed in a special section.

The Register, which is compiled by the publishers in close collaboration with the F B I, is used by importers, Trade Commissioners, Chambers of Commerce, reference libraries and government and industrial purchasing agents throughout the world.

This is the 33rd edition of the Register, and like its predecessors it provides an invaluable source of information on the wide range and scope of the products and services offered by all sections of British industry.

Electrotechnology for National Certificate Courses. Volume 3. *By H. Buckingham and E. M. Price.* $8\frac{3}{4} \times 6$ *in* (222 × 152 *mm*). *Pp* viii + 361. *Illustrated. Index.* (*London: The English Universities Press Ltd.*) Price 16s net.

This new book is one of the publisher's Technical College Series of books which have been prepared for the use of students, especially part-time, working in Technical Colleges.

This is the third volume of a set which covers in a progressive theme the subject matter of the Ordinary National Certificate course in Electrical Engineering. The reader is presumed to be fully familiar with the ground-work covered in volumes one and two. The authors have not restricted the subject matter to what is normally included in the S 3 year so that some of the topics are more appropriate to an A l course.

In the fourteen chapters of this book, illustrated by 295 line diagrams and some photographs, the authors discuss successively: d c armature windings, characteristics of d c machines, operation of d c machines, electric and magnetic fields, electric circuit theory, polyphase a c systems, transformers, rotating fields, conversion of a c to d c, electronics, and finally some economic considerations.

The general treatment given to these topics is based on the idea of presenting a short piece of book work, and following it up with either, or both, an illustrating experiment or a fully worked numerical example. This method is popular with students as it deals with each topic, without padding, in a very direct manner.

The treatment, although mathematical, does not use any involved analysis and is nowhere beyond the reasonable attainment of the reader for whom the book has been prepared. The solution of the alternating current circuit is based upon the symbolic notation and this is not a wise procedure. Experience shows that initially students should be taught to base the solution of the alternating current circuit on the vector diagram. This approach tends to inculcate in the student a better appreciation of the phase differences between the represented quantities.

The authors have provided throughout the text a total of 60 fully worked examples to show how the theoretical principles are applied to the solution of practical problems. There are also at the end of each chapter further problems, in all 196, by which the reader can test the progress he is making in his studies. At the end of the book there are 13 tables of useful data, and also a list of 13 experiments which are fully described in the text.

This is an attractively produced book, which gives a good progressive approach to the subject without too much pedestrian treatment. It is well written, easily read and clearly printed on good quality paper. The book is well worth possessing and is strongly recommended for the type of student for whom it has been prepared.

P. F. SOPER

Electromechanical Energy Conversion. *By D. White and H. Woodson.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp* xv + 646. *Illustrated. Index.* (*London: Chapman & Hall.*) Price 100s net.

This book, one of several that have been produced following a recent revision of the Electrical Engineering Course at the Massachusetts Institute of Technology, provides a comprehensive mathematical analysis of the operation of a wide variety of electrical machines and apparatus. As the authors remark in the Preface, 'the increasing complexity and diversity of electrical technology, both theoretical and applied, and the limits of time set by the conventional four-year college program make it necessary to subordinate the detailed behaviour and design of contemporary devices to scientific concepts and the techniques for their exploitation'. Moved by this objective the authors have written a book that, though in places making rather heavy demands on the reader's grasp of mathematical abstraction, must be recognised as a highly successful attempt to generalise the study of the behaviour of electrical apparatus under all conditions.

In the conviction that the analysis of electromechanical devices based upon steady-state concepts using equivalent circuits and the elementary ideas of

network theory is inadequate for a clear understanding of the behaviour of these devices, the authors have discarded much traditional material regarding steady-state characteristics and device design. In place of this they have given a thorough treatment of the dynamic characteristics of energy converters, feed-back control system theory and their inter-relations.

A brief introduction to the calculus of variations leads to the statement of Hamilton's principle and the derivation of Lagrange's equations of motion, whose use is exemplified by the analysis of several simple transducers. This section concludes with a varied selection of highly instructive exercises. Next follow a discussion of mathematical techniques for solving equations of motion, the method of Laplace transforms, determination of frequency response, the 'algebra' of block diagrams, techniques for the study of non-linear differential equations and an introduction to the principles of analogue computers. These two introductory chapters provide a most valuable account of the basic methods of solution of electromechanical problems.

The following two chapters present a unified treatment of the dynamics of rotating machines, integrating the earlier work of Kron, Gibbs and others. On the basis of a general physical model comprising concentric magnetic cylinders with current sheets on their surfaces, general equations of motion are derived which, by suitable constraints to the general model, can be made to yield the complete dynamic equations of a wide variety of machines. The effect of a commutator may be taken into account and, in the words of the authors, '*one* physical model with *one* set of equations describes all of conventional steady-state and dynamic characteristics of many unconventional machines'. As might be expected, this happy result has been achieved at the cost of considerable mathematical abstraction, and this part of the book will probably be found difficult to digest.

Next appears a simple introduction to the theory of feed-back control systems, and the remaining chapters are devoted to detailed consideration of the dynamics of transducers, commutator machines, induction machines and synchronous machines. The book concludes with two chapters on the analysis of a machine with an n-phase stator and an m-phase rotor, and on space harmonic analysis. There is a large number of problems for solution.

This is clearly a work of great authority. Although the mathematical presentation may in places be found very abstract this is probably inevitable in any treatment of so highly generalised a character, and there is no doubt that this book will quickly become recognised as a leading work of reference in this field.

S. A. SWANN

Problems in Engineering. *By S. Parker Smith.* $8\frac{1}{4} \times 5\frac{1}{2}$ *in* (222 × 140 *mm*). *Pp xvii* + 342. *Illustrated. Index.* (*London: Constable & Co. Ltd*, 1960.) Price 18s net.

This is the seventh edition of a well known set of tutorial problems dealing with the theory and practice of electrical engineering which was first published in 1929.

In each successive edition the opportunity has been taken to add new problems, often dealing with new topics. Naturally the earlier editions gave greater emphasis to problems in general electrical engineering, but the present volume gives adequate attention also to light current subjects. The book opens with a preparatory section which deals with nomenclature abbreviations, physical constants, unit systems, miscellaneous constants and conversions, standard curves and the sign convention for electronic amplifiers.

The 1981 problems illustrated by 273 diagrams in the present edition contain over 100 new problems dealing with topics such as semi-conductors and the pulse testing of lines and amplifiers.

No course of instruction can be successful unless equal attention is given to the lecture tutorial and laboratory work of the course. In general, students only really learn and obtain a thorough knowledge about those parts of a subject upon which they themselves have worked. Properly organised and well-run tutorial classes are one of the methods of helping students to help themselves. Adequate staff must be available, however, to provide assistance where this is necessary, but spoon-feeding should not be encouraged.

Staff time and energy are conserved in such tutorials when there is available a book of well thought out example. The present book fulfils this need in the broad field of electrical engineering. It should be possessed by all serious students of electrical engineering and they should endeavour to solve the complete set by the time they finally qualify. These students who do in fact work out all these problems will have a sound foundation for their future work. The existence of this book means that lecturers need no longer prepare their own lists of problems, with the resultant waste of energy which this entails.

Electronic Circuits, Signals and Systems. *By Samuel J. Mason and Henry J. Zimmermann.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp xviii* + 616. *Illustrated. Index.* (*London: Chapman & Hall*, 1960.) Price 100s net.

In 1959 the authors published a book, *Electronic Circuits Theory, Devices, Models and Circuits*, in which elementary linear circuit theory was extended to electronic circuits and in which most of the circuit functions involve non-linear operations. The present book is a companion volume and it presents methods for handling more general circuits to which more general signals are applied.

Following an introductory chapter there are four relating to methods of circuit analysis in a modern setting. They deal with matrix analysis, topological analysis, linear signal-flow graphs and flow-graph analysis. Chapter 6 is on signal analysis and it introduces Fourier theory and its application to the description of signals. Chapter 7 covers the transmission of signals through linear systems, employing amplifier circuits for illustration, and transfer techniques and convolution as the mathematical means. Chapter 8 is on non-linear and time-varying linear systems while chapter 9 deals with the negative-feedback concept, through the medium of the analytical and topological methods previously described. Problems are given —without answers—at the end of each chapter.

The central feature of the book is signals, and to focus on this we may pertinently quote from the introductory chapter: 'Electronic systems can be defined broadly as combinations of circuits that process signals . . . The distinction between circuits and systems depends more on the point of view than on complexity. The system viewpoint emphasises operation functions or input-output relations. The circuit viewpoint is concerned with the determination of currents and voltages for branches or loops of a circuit. System theory is involved with signal transmission or signal processing; circuit theory with the realisation of circuits to perform the the necessary function or carry out the processes'.

There is the essence of the book, linking together the three topics covered by the title. The objects are clearly defined and the routes taken to reach them are even more clearly and carefully explored. It would be difficult to improve on this first-rate text, which has resulted from teaching in the electrical engineering course at M I T, and the authors are to be congratulated on having written it.

S. AUSTEN STIGANT

Numerical Methods for High-Speed Computers. *By G. N. Lance.* $8\frac{3}{4} \times 5\frac{1}{4}$ *in* (222 × 146 *mm*). *Pp* x + 166. *Illustrated. Index.* (*London: Iliffe*, 1960). Price 42s net.

In 1952 Professor Hartree, whose contributions to the field of numerical analysis are well known, made the following statement in the last paragraph of his book on numerical analysis: 'Some work has been done on the development of methods particularly suited to the capabilities and limitations of automatic machines, but the main developments of numerical analysis probably still lie in the future.' It is now commonly accepted that this is true, and that many of the methods developed exclusively for desk machine calculation do not take full advantage of the facilities provided by high-speed computers. In addition, methods have recently been developed that are applicable only to high-speed machines.

With this position as a background it is a pleasure to meet a book which has been written with the needs of the digital computer user directly in mind and which attempts to fill a gap in the literature that has long been apparent. Further, there can be no doubt that Dr Lance is well qualified to write this book, having extensive past experience in the use of digital computers for the solution of numerical analysis problems.

The introductory chapter gives an outline of the general features of digital computing machines, and of the reasons why different numerical methods are necessary if an automatic computer is to be used instead of a hand computer. As one example of the latter, on a hand machine it is usual

to use a fairly accurate integration formula for the numerical solution of differential equations, whereas with a digital computer it is preferable to use a very simple formula but to apply it a very large number of times. Chapter 2, the longest chapter of the book, is concerned with methods for the evaluation of functions using a digital computer, both standard functions such as logarithmic, inverse circular, Bessel functions etc, and also economisation of power series and other applications involving the use of Chebyshev polynomials.

Next follows a chapter devoted to the solution of ordinary differential equations, including reference to stability, the use of the Runge-Kutta method and recent modifications of this method, and a description of some of the author's own work showing how a jury-type problem can be converted into a marching-type problem which can then be solved by simpler described methods. Chapter 4 details matrix methods suitable for high-speed computers, including the calculation of latent roots and vectors, matrix interpretative schemes for simplified matrix algebra programming, and matrix inversion.

The numerical solution of partial differential equations is the subject of the next chapter, and attention is confined, with a few exceptions, to linear second-order partial differential equations with two independent variables, account being taken of non-rectangular boundaries and stability where relevant. The final chapter details methods of solution of diverse problems in numerical analysis, including the solution of transcendental and polynomial equations, continued fraction evaluation, interpolation, numerical integration and inverse Laplace transformation of a ratio of polynomials. The book closes with a short appendix on floating-point arithmetic, a bibliography of more than a hundred references, an author index and a subject index.

There are so many individual points of interest in this book that it is impossible to do justice to the work in the space of a review. This is primarily because much of the material in this rapidly changing subject is taken from recently published papers and is not so widely known as it might be. Consequently, the author has performed a valuable service in writing this book, which should find a wide audience among engineers, physicists, chemists, mathematicians, programmers, and others concerned with the solution of numerical analysis problems using high-speed computers.

The book is well produced, well written and contains a wealth of useful work and detail at a very reasonable price.

H. GOLDENBERG

Applied Electricity. *By H. Cotton.* $8\frac{3}{4} \times 5\frac{1}{4}$ *in* (222×146 *mm*). *Pp xii* + 516. *Index. Illustrated.* (*London: Cleaver-Hume Press Ltd*, 1960.) Price 25s.

This is the fourth edition of this well known textbook and it is a tribute to the general popularity of the book that a new edition is so soon required. With the need for a new edition the author has taken the opportunity to extend considerably the section on electronics and has included information on non-linear resistors and semiconductors. At the same time many new examples have been added to those to be worked out by the reader in order to test his understanding of the subject. All the 311 examples are grouped together at the end of the text.

The general arrangement of the 21 chapters of this book is unchanged from the last edition. The text is illustrated with 412 line diagrams and half-tone illustrations together with 19 tables. There are also throughout the book numerous fully worked numerical examples to demonstrate the application of the fundamental principles and concepts.

The book was originally prepared by the author to meet the requirements of students who were studying the subject of applied electricity in the Part I Examination (Old Regulations) for the engineering degree of the University of London. In consequence the book with the additions made with each edition now contains more material than can possibly be covered, or even needs to be included, in the same subject under the Revised Regulations. This should not however deter intending readers as naturally the material not required for this examination is mainly dealt with in the latter chapters of the book.

The text uses the M K S μ system of units throughout. There are a number of non-standard unit abbreviations used especially in the problems; this is not a good example to students and should be corrected in the next issue.

P. F. SOPER

Transformers and Generators for Power Systems. *By R. Langlois-Berthelot.* $9 \times 5\frac{1}{2}$ *in* (229×140 *mm*). *Pp ix* + 541. *Index. Illustrated.* (*London: Macdonald & Co Ltd*, 1960). Price 65s.

This very useful book is addressed chiefly to supply system engineers, to many of whom it might almost become a 'bible'. To only a somewhat lesser extent it will appeal to students and to transformer and rotating machine specialists, although it refrains from delving into design details and procedures.

Apart from the student interest the book is particularly written for supply engineers who prepare the technical purchasing specifications and for system operating engineers who have to live with the idiosyncrasies of the plant. Therefore, and rather broadly, the book embraces studies of machine behaviour, capabilities, and rating. The two kinds of plant, transformers, and generators, are kept quite separate and, in fact, the book is really two in one.

In respect of transformers the volume deals with steady-state theory, winding arrangements, insulation, losses, temperature rise and cooling, abnormal conditions, regulation means, phase connexion, special types, guides for specification and operation engineers, and special-purpose units.

The second half, on synchronous machines, covers steady-state conditions, insulation, losses, cooling and temperature rise, transient conditions, and guides for specification and operation engineers.

For both classes of plant there are surveys of the technical literature for 1950–54 and 1954–58.

The book contains a great deal of most useful information and guidance of an essentially practical nature and it can be recommended without hestitation to all those working in the electrical power field, from students upwards.

Electromagnetic Fields, Energy, and Forces. *By R. M. Fano, L. J. Chu, and R. B. Adler.* $9\frac{1}{4} \times 6\frac{1}{4}$ *in* (235×159 *mm*). *Pp xv* + 420. *Illustrated. Index.* (*New &ork: Wiley; London: Chapman & Hall*, 1960.) Price 96s net.

This textbook is for students in electrical engineering and has two main objectives: the development of a consistent macroscopic theory of electromagnetism, and the investigation of the relation between circuit theory and field theory. The scope of the book is indicated by the chapter titles, which are as follows:—

1. The Integral Laws in Free Space.
2. Vector Analysis.
3. The Differential Laws in Free Space.
4. Static Fields.
5. Fields and Matter.
6. Time-Varying Fields.
7. Electromagnetic Energy and Power.
8. The Sinusoidal Steady State.
9. Electromagnetic Fields in the Presence of Moving Matter.
10. Forces and Energy in Moving Systems.

There is also an appendix for advanced workers dealing with the relativistic macroscopic formulation of electromagnetism, recently developed by one of the authors.

Priority throughout has been given to basic principles and methods of analysis rather than to the presentation of current technology. As might be expected the solution of the special boundary-value problems of electromagnetic theory is not one of the objectives of this book, owing to the comparative complexity of the mathematical techniques involved. The synthesis point of view, namely that it is usually easier to synthesise an electromagnetic system with prescribed properties than to analyse one that is completely specified, is emphasised in the text and through examples. Problems are included at the end of each chapter, but the corresponding solutions are not given.

The book as a whole is lucidly written and well produced. There is little doubt that it will prove successful for the purpose for which it is intended.

H. GOLDENBERG

Principles of Electricity and Magnetism. *By Y. Rocard.* $8\frac{1}{4} \times 5\frac{1}{2}$ *in* (222×140 *mm*). *Pp x* + 779. *Illustrated. Index.* (*London: Iliffe & Sons.*) Price 70s net.

This is a translation of a French treatise on electricity and magnetism which was first published in 1951. The text is based on a lecture course given at the Sorbonne during the 1941-42 session, together with certain other topics which came into prominence during the war years.

The contents of the 48 chapters of the book, illustrated with 686 figures and

diagrams, are intended for those students who are taking a University course in Physics. The treatment is essentially mathematical and abstract in the sense that there are no numerical examples to illustrate the text. There are no references provided for further or wider reading, and there are no examples for the reader to test his grasp of the subject matter.

The text covers such a vast number of topics that it is clearly impossible for more than a superficial treatment to be provided. Nevertheless, the book serves a valuable purpose, not only for general reading but in providing an introduction to any of the topics dealt with by the author. Most of the mathematics employed are, however, not beyond the reach of many other types of students who are not following undergraduate courses.

The book is clearly printed on good quality paper, and the general format is attractive. The book is well worth possessing, despite the rather high price.

P. F. SOPER

Alternating Current Machines. *By H. Cotton.* $7\frac{1}{2} \times 5\frac{1}{4}$ *in* (190 × 133 *mm*). *Pp* 328. *Illustrated.* (*London: Cleaver-Hume Press Ltd.*) 1960. Price 21s net.

Professor Cotton has produced in this second edition of *Alternating Current Machines* a concise, well-illustrated and a highly readable book which deals extensively with the commonest types of electrical machines. It should appeal especially to the non-specialist student mainly because the treatment of the book is not mathematical.

This author is well known for his ability to convey physical principles in words; this in itself makes the book a joy to read, particularly for those with a semi-technical, or even no technical, background.

The new edition makes reference to British Standards where these apply, and includes new material on the single-phase series commutator and the universal motors now produced on a vast scale for domestic appliances and, in tabular form, a chapter on the choice of motors for special purposes.

This inexpensive little volume is a worthwhile acquisition by any reader who wishes to keep up-to-date with this aspect of electrical engineering.

Electrical Safety. *By H. W. Swann,* $8\frac{1}{2} \times 5\frac{1}{2}$ *in* (216 × 140 *mm*). *Pp* 288 *plus index.* 96 *illustrations.* (*Macdonald & Co (Publishers) Ltd.*) Price 40s net.

When it is recalled that Mr Swann was for very many years the Senior Electrical Inspector for the Home Office of the British Government, it is obvious that practically no other person in Great Britain could be better fitted to write a treatise on electrical safety. It was the duty of the engineering inspectors in his department to conduct an exhaustive investigation into the causes of every electrical accident, and it was Mr Swann's duty to analyse the vast amount of material so produced and to endeavour to take such action as he felt possible to reduce the accident rate.

The first surprising fact that emerges is that even with the great increase in the usage of electrical energy, the electrical accident rate does not increase to anything like the extent that might have been thought possible. For example, Mr Swann tells us: 'Looking at the year 1953, when there were 784 electrical factory accidents in total, the Central Electricity Authority supplied over 42 000 million units (for 1952-53)—more than 21 times the 1923 figure, but the electrical accident rate has only doubled and rather seems to have settled down to between 700 and 800 in the last ten years'.

Again, with the very great increase in the number of domestic electrical appliances in use in British homes when the year 1945 is compared with 1955, it is surprising to find that fatal domestic electrical accidents in fact decreased from 48 in 1945 to 39 in 1955, and the highest figure in any intervening year was 54.

However, Mr Swann warns us that *fatal* shock requires the simultaneous occurrence of a number of factors, and since there may be many hundreds of thousands of occasions in the domestic and industrial usage of electrical equipment where all the conditions for a fatal accident except one are fulfilled, there is no room for complacency.

The author naturally discusses the Electricity Regulations at some length, and this chapter should prove to be an invaluable guide to those who may be in charge of operatives engaged on any sort of electrical process. Mr Swann takes pains at every stage to show how possible electrical risks may arise, and how the Regulations should be applied. Subsequent chapters deal with adequacy of equipment, automatic protection, switchboards, and the special regulations concerned with inflammable surroundings.

The chapter on static electrification is one which has been badly needed since there has been much scattered literature on this subject but little by way of an electrical engineer's approach to the problem as a whole. It is however a little disappointing to find that Mr Swann sometimes ends a fascinating account of troubles which had mysteriously arisen and had then been tracked down to the accumulation of static charges without telling us very much about the resulting lessons to be learned in future installations.

There is a useful appendix on domestic electrical installations, reprinted from Mr Swann's own paper to the Institution of Electrical Engineers on this subject. He reaches the conclusion that insufficient attention is paid to the protective arrangements in most domestic installations, 'recognising that changes of method may become necessary so that the assumption that the fuse will blow if anything goes wrong will in effect be justified'.

It may well be assumed that Mr Swann, as a distinguished civil servant, felt it desirable to refrain from making recommendations which might have been interpreted as official Government policy. Thus he frequently leads up to a point where one expects a positive recommendation, but then seems to turn away and say, in effect: 'I have now shown you where trouble may occur, and why; it is now up to you to draw your own conclusions as to the best methods of prevention'.

J.H.M.S.

SHORTER BOOK REVIEWS

Information Transmission, Modulation, and Noise. *By M Schwartz.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp xv* + 461. *Illustrated.* (*London: & New York: McGraw-Hill.*) Price 85s 6d net.

Intended as a graduate level textbook, it covers the fundamental role of system bandwidth and noise in limiting transmission of information, and stresses the principles of modern telecommunication systems.

Noise in Electron Devices. *Edited by L D Smullin and H A Hans.* $9\frac{1}{4} \times 6$ *in* (125 × 152 *mm*). *Pp xvi* + 413. *Illustrated.* (*New York: John Wiley; London: Chapman & Hall.*) Price 96s net.

A comprehensive discussion, stressing the mathematical theory and basic physical phenomena rather than design techniques.

A New Method in the Theory of Superconductivity. *By N N Bogolusbov and others.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp iii* + 121. *Illustrated.* (*New York: Consultants Bureau; London: Chapman & Hall.*) Price 50s net.

A translation from the Russian of a new method based on a physical and mathematical analogy with superfluidity.

Phototubes. *Edited by A Schure.* $8\frac{1}{2} \times 5\frac{1}{2}$ *in* (216 × 140 *mm*). *Pp vii* + 88. *Illustrated.* (*New York: John F Rider; London: Chapman & Hall.*) Price 15s net.

This book presents information dealing with phototubes and their amplifiers and circuits. The use of mathematics has been kept to a minimum.

Lectures on Nuclear Theory. *By L Landau and Ya Smorodmsky.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp vii* + 108. *Illustrated.* (*New York: Plenum Press; London: Chapman & Hall.*) Price $5.25.

A translation from the Russian of a series of lectures given by one of the authors to experimental physicists.

Fundamentals of Radio Telemetry. *By M Tepper.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp viii* + 116. *Illustrated.* (*New York: John Wiley; London: Chapman & Hall.*) Price 24s net.

Only a basic knowledge of electronics is required by the reader to understand this work on the telemetry of guided missiles and supersonic aircraft.

Non-linear Problems in Random Theory. *By N Wiener.* $9\frac{1}{4} \times 6$ *in* (235 × 152 *mm*). *Pp ix* + 131. *Illustrated.* (*New York: John Wiley; London: Chapman & Hall.*) Price 24s net.

Based on a series of lectures given by the author to a special group of advanced students at MIT, where he is Professor of Mathematics.

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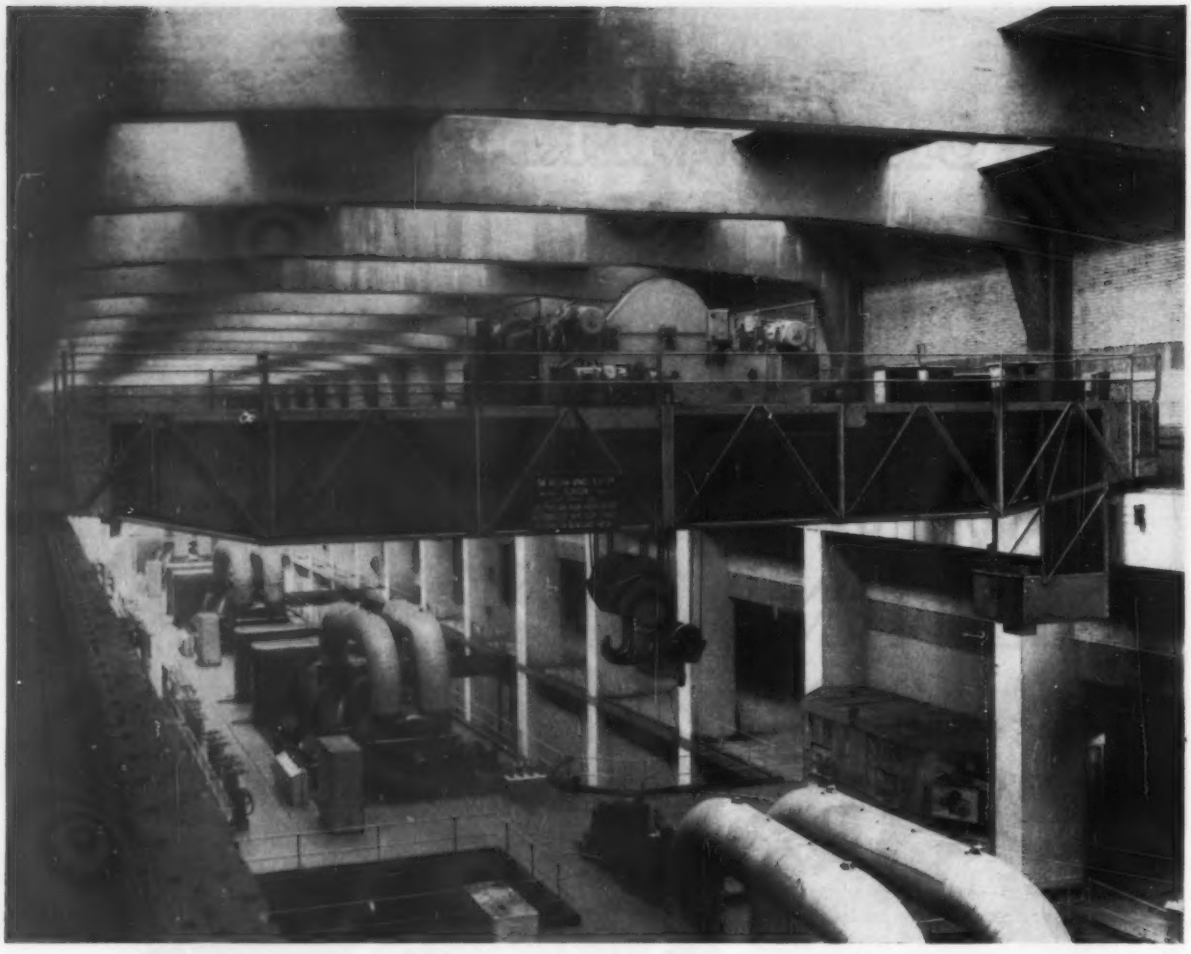

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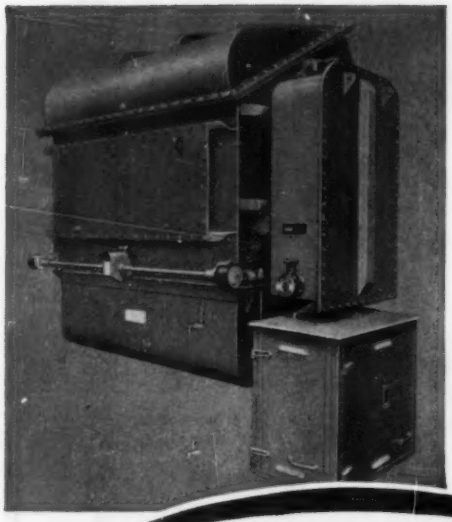

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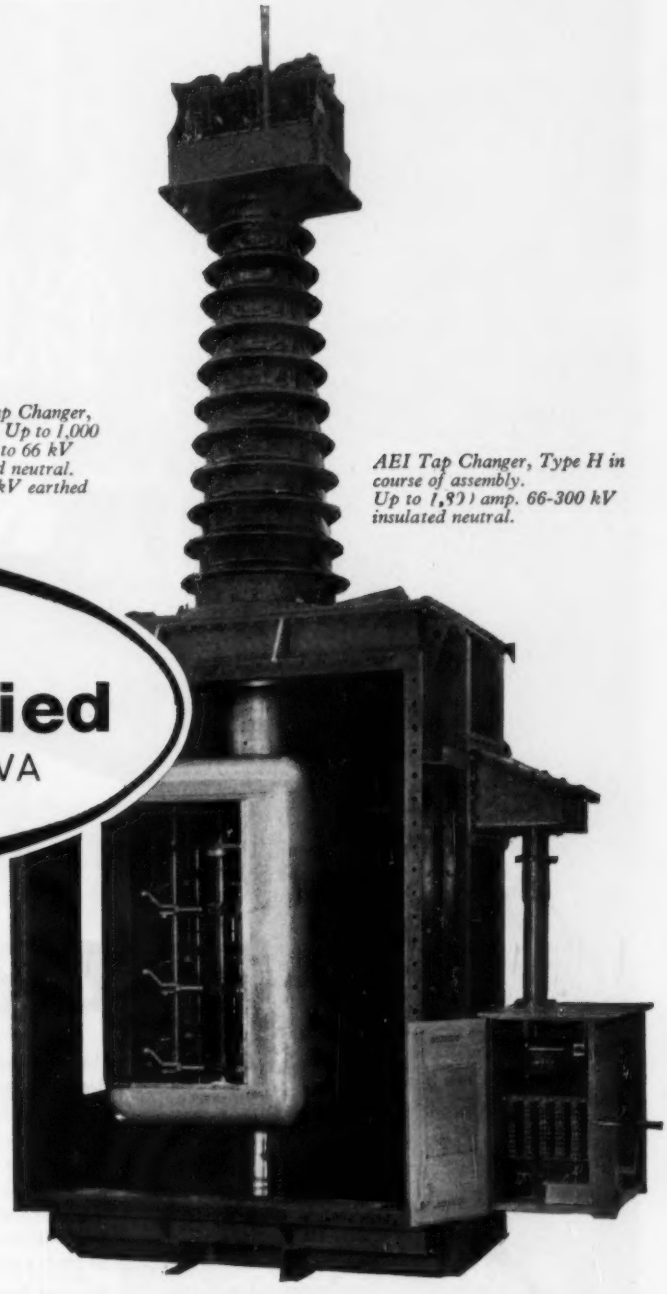

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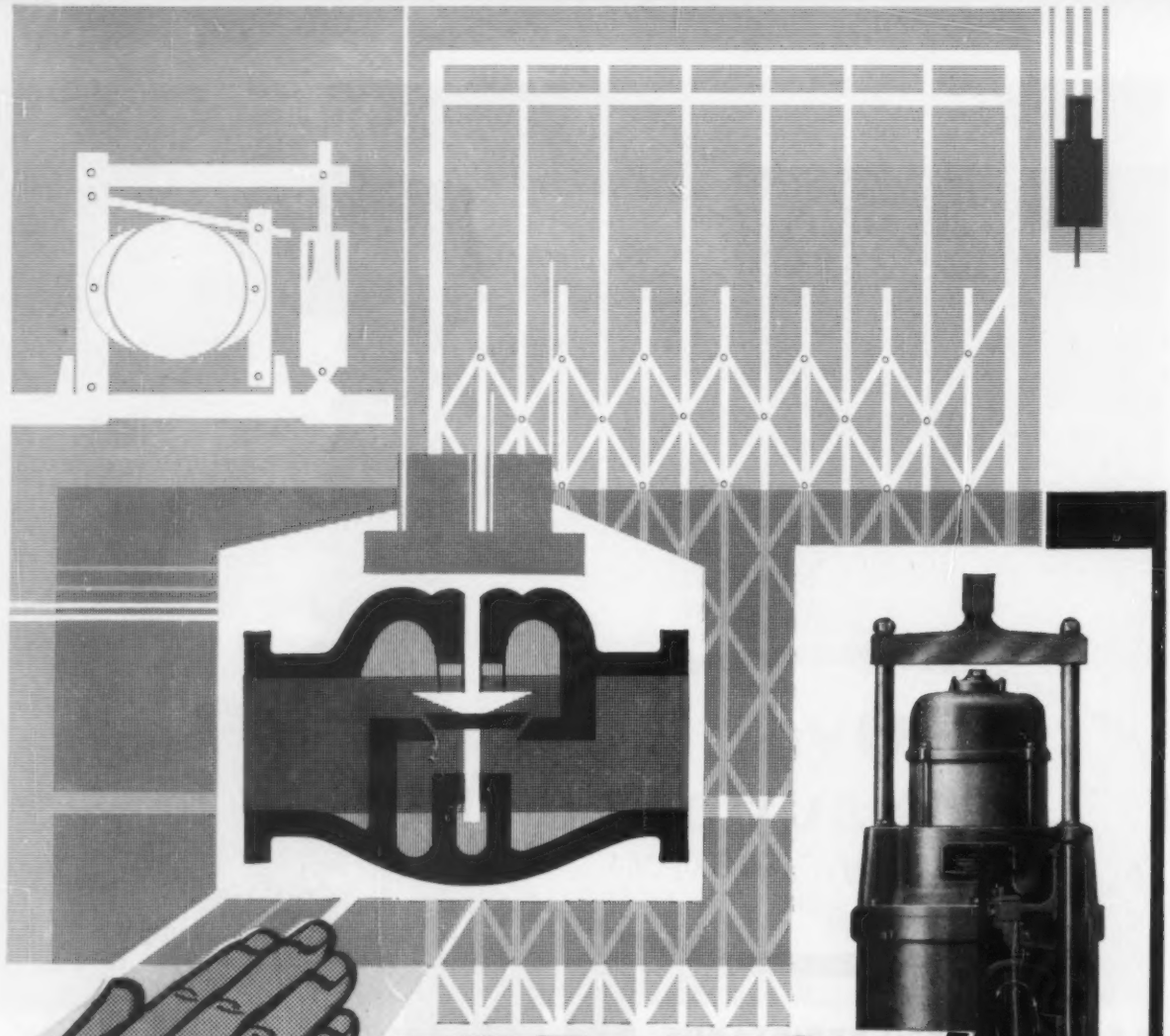

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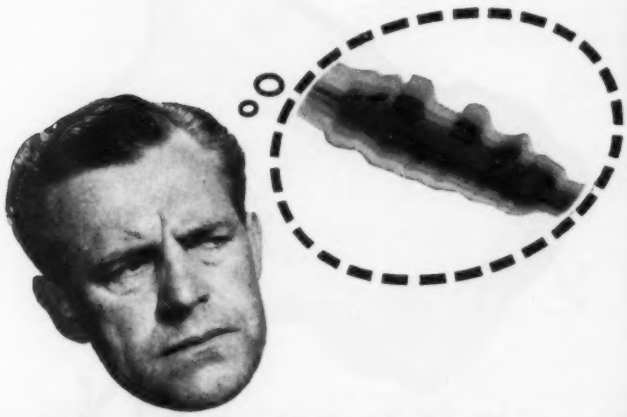

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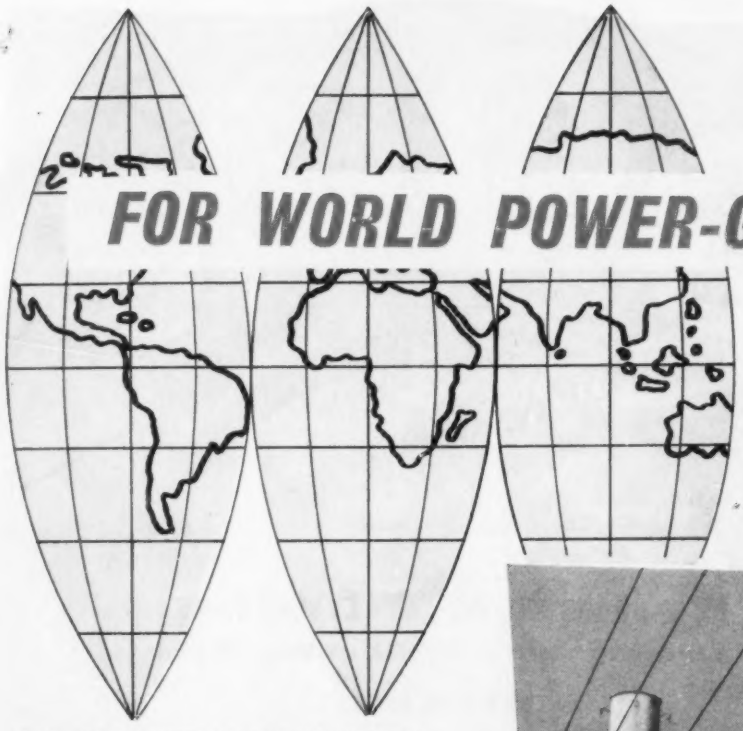

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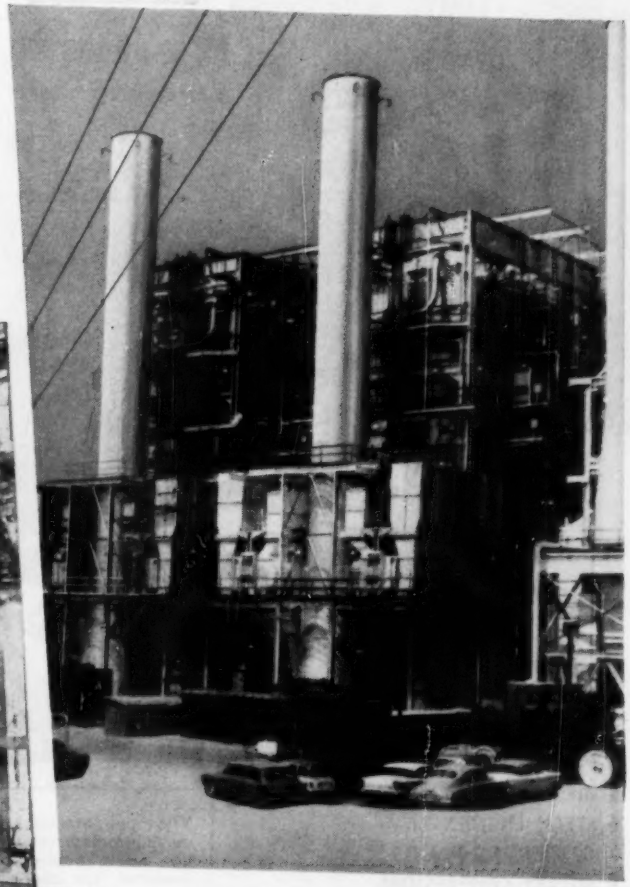

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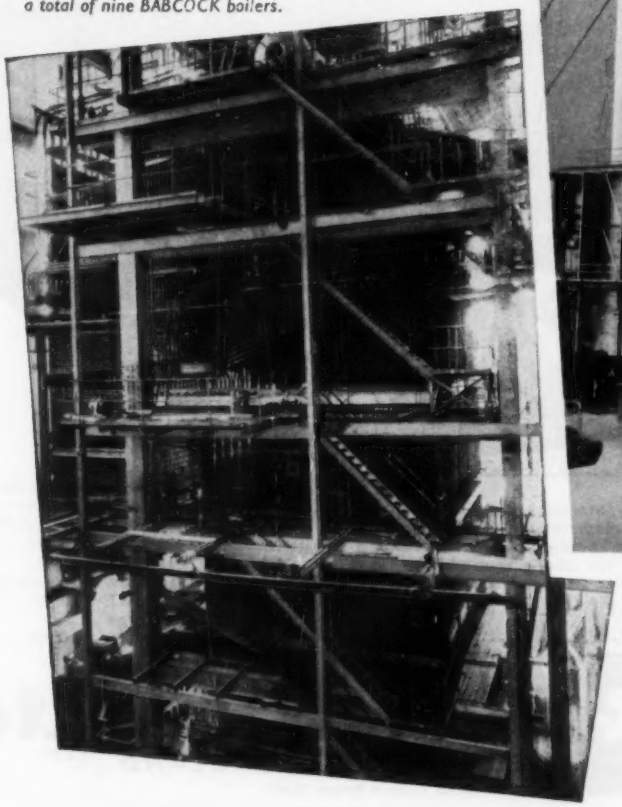

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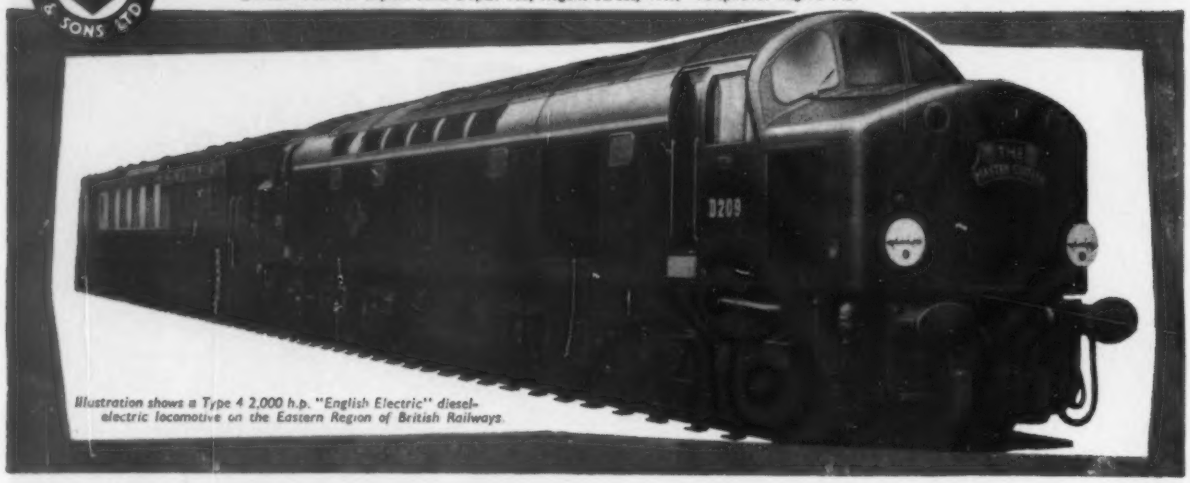

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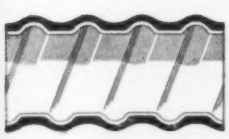

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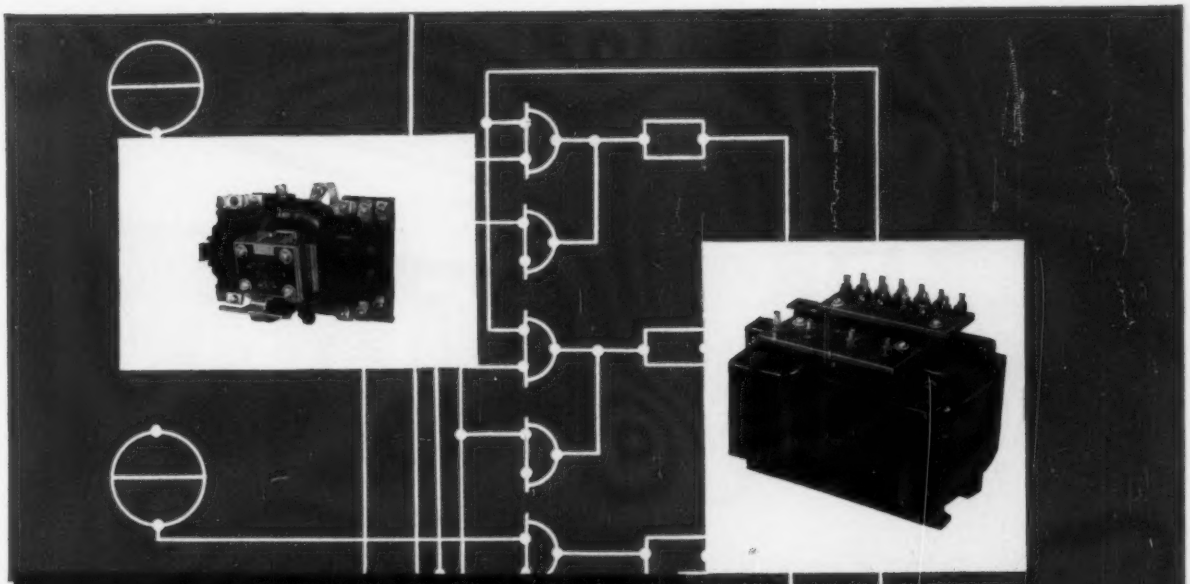

the pattern of
CONTROL
and the circuitry behind it

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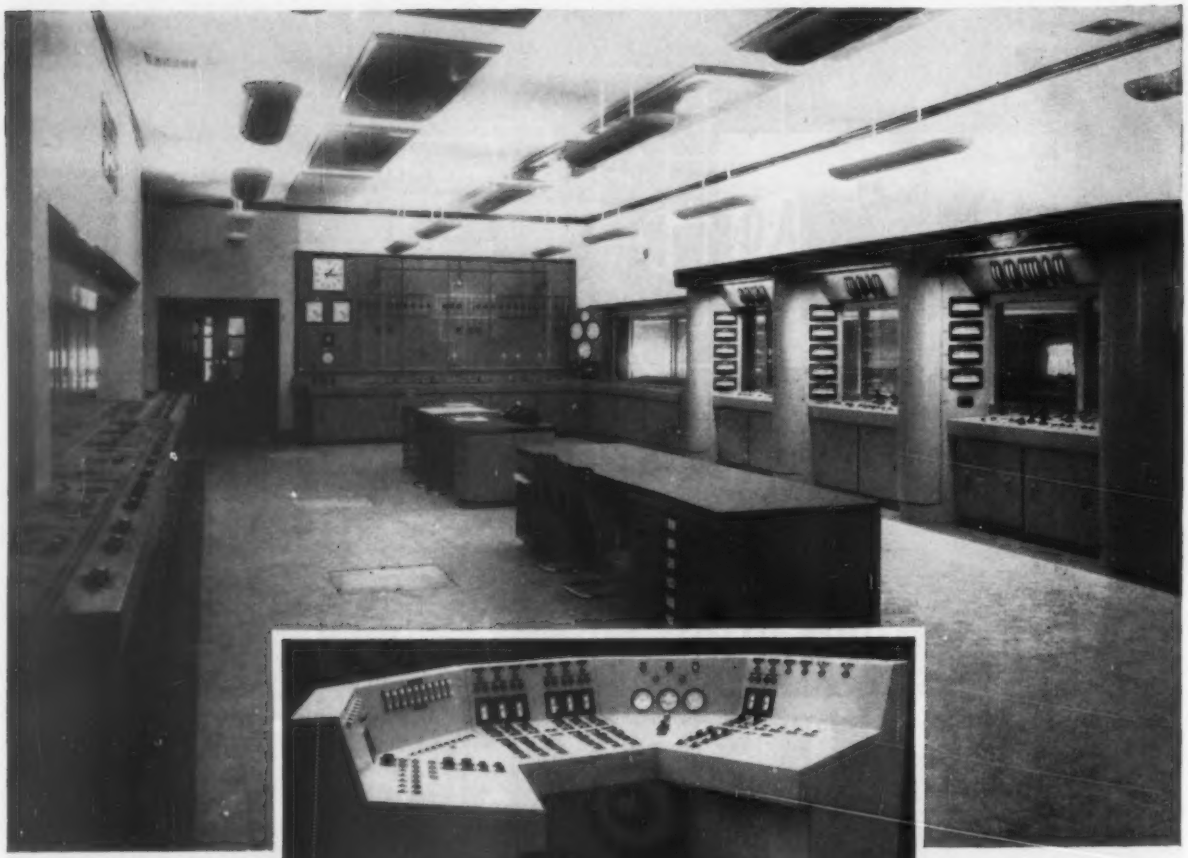
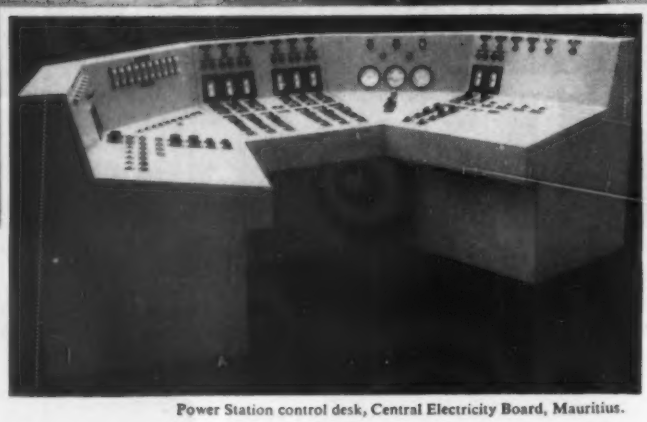


Main Control Room, Ashford Common Pumping Station of the Metropolitan Water Board.



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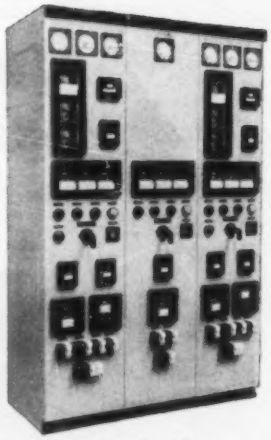

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S6

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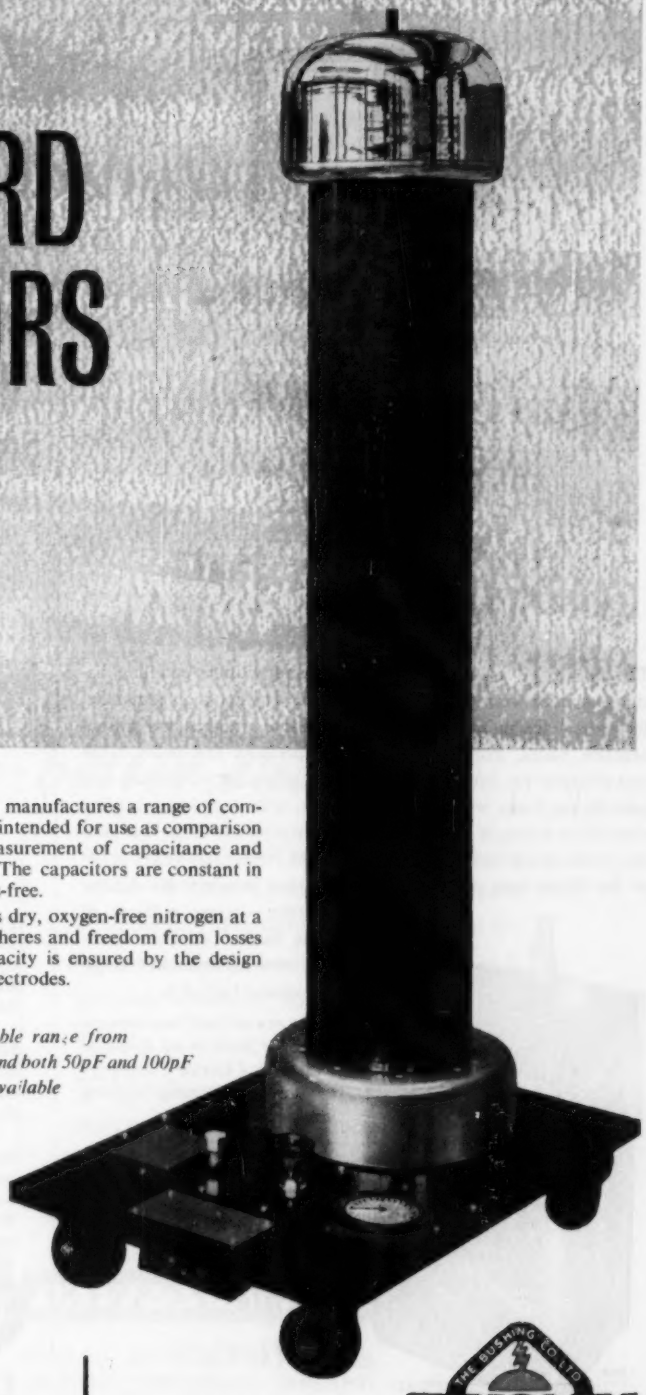

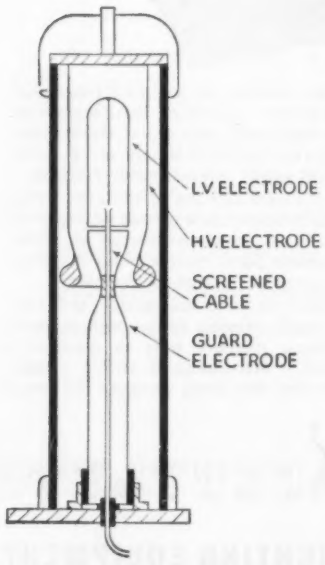

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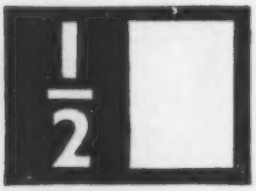

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We manufacture all types of Stator and Rotor Starters for controlling Slip Ring Motors, both of the hand operated, oil immersed or liquid starter type and also the contactor type. Typical examples are illustrated.

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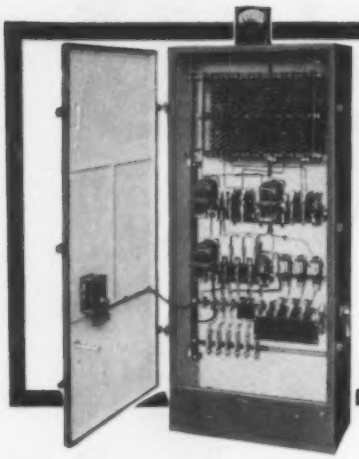
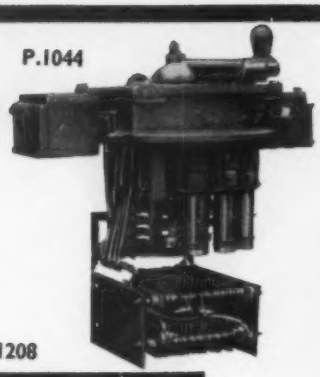


P.1208



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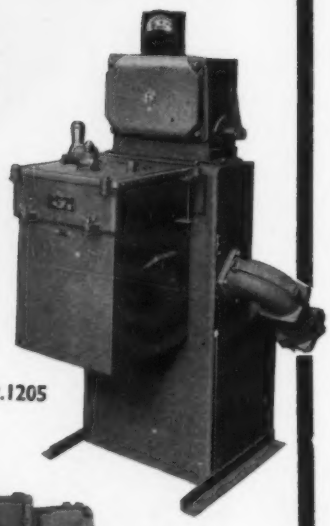

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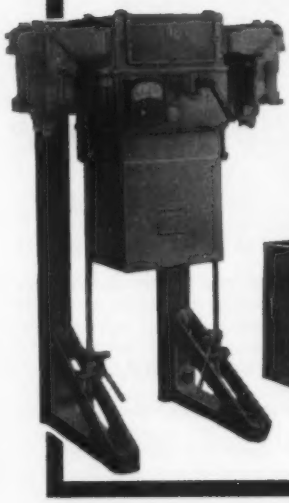

P.1025

P.924

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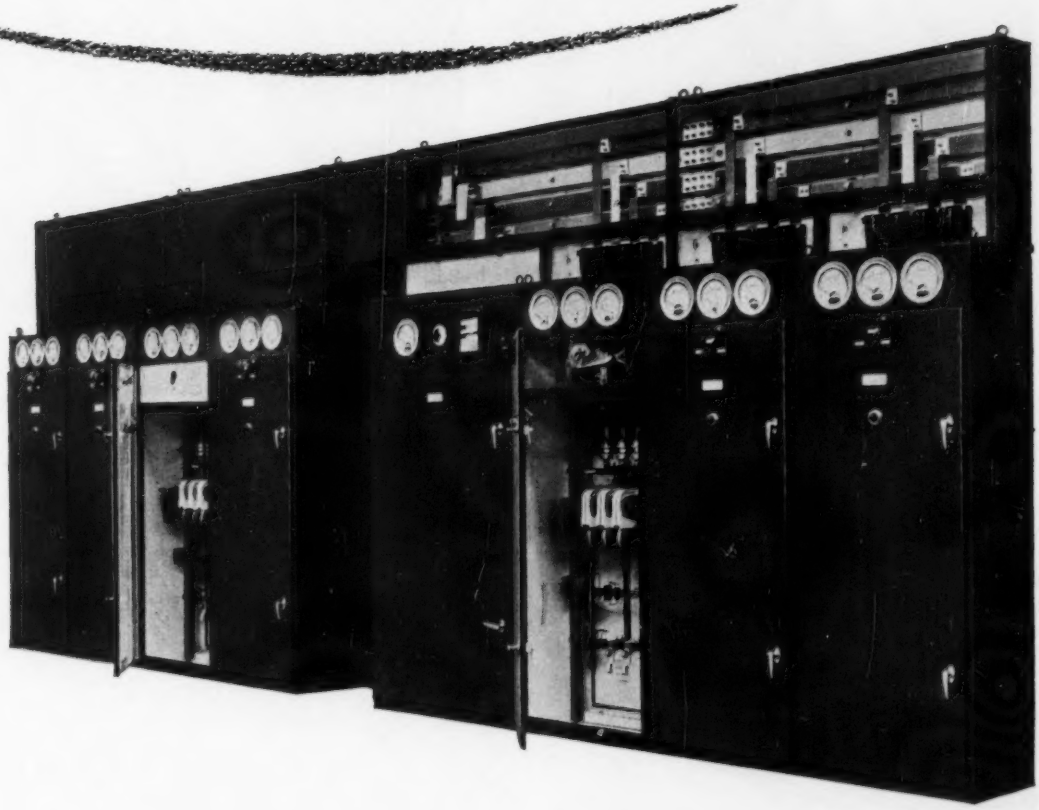

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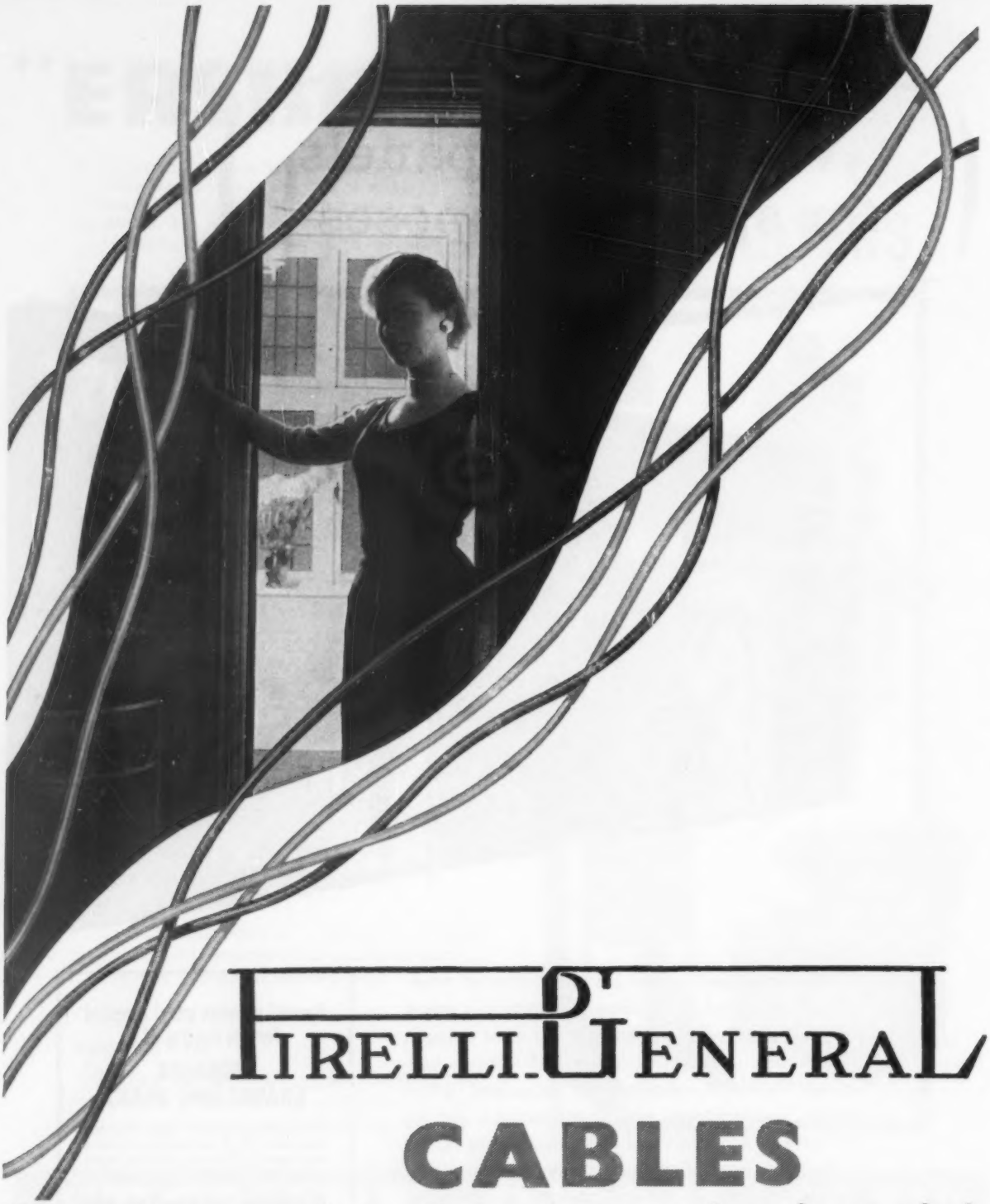

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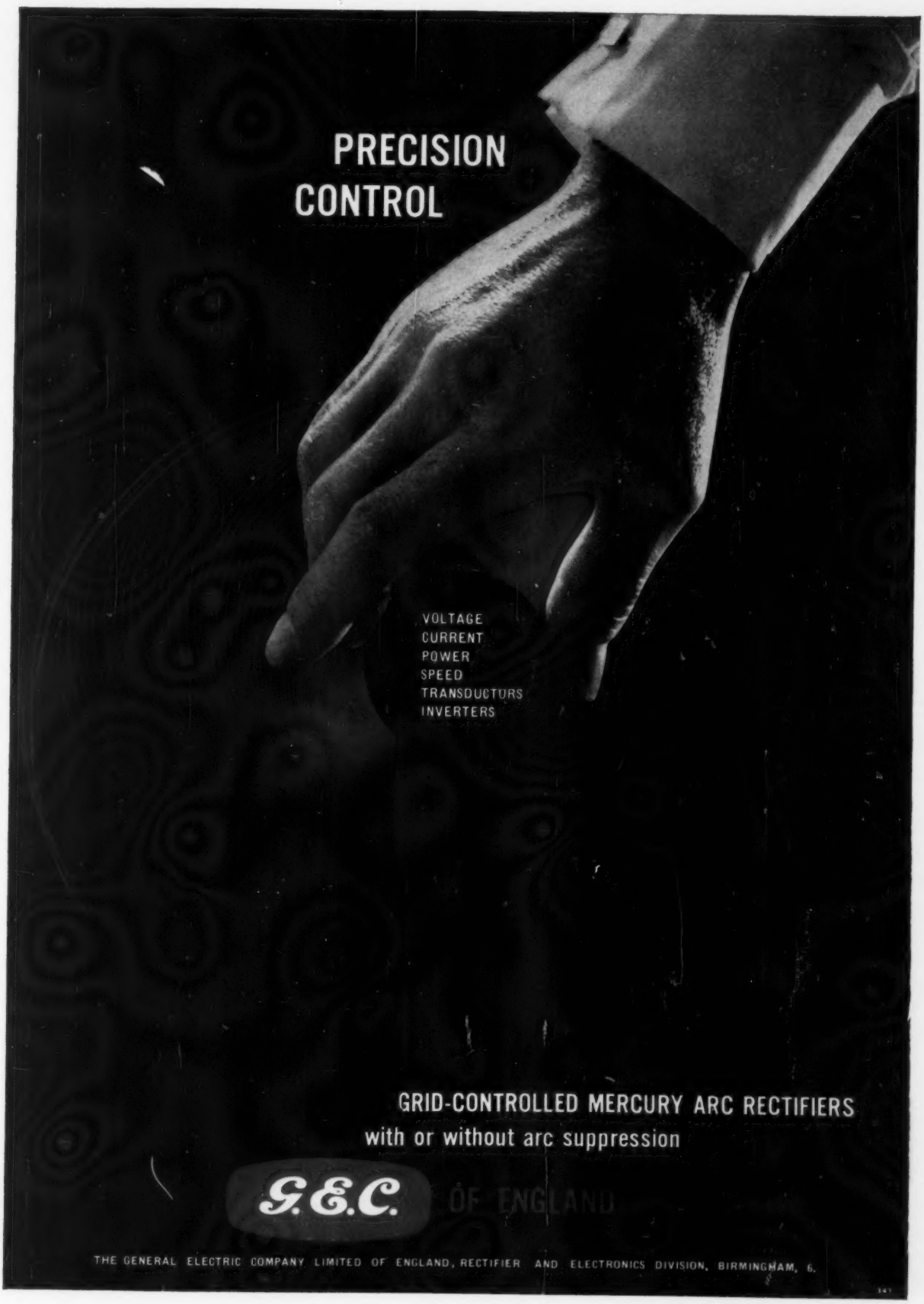
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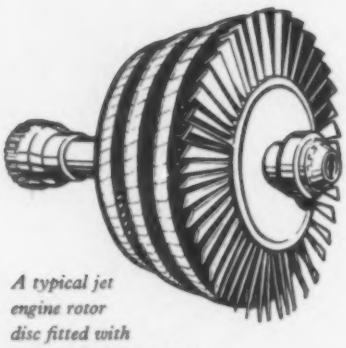

A typical jet engine rotor disc fitted with Garringtons' forged blades.

It most certainly is—for aircraft engine manufacture is one of the many important industries benefiting from induction heating equipment produced by Garringtons. Turbine and compressor blades for jet engines, heated for forging by this proved method, are used in such world famous engines as Rolls-Royce "Avon", Curtiss-Wright "J.65", Armstrong-Siddeley "Sapphire", Bristol "Olympus" and "Orpheus", to mention but a few.

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Quality — Improved as a result of automatic control which ensures consistent scale free heating to specification.
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A NEW EMI HIGH TORQUE BATTERY MOTOR

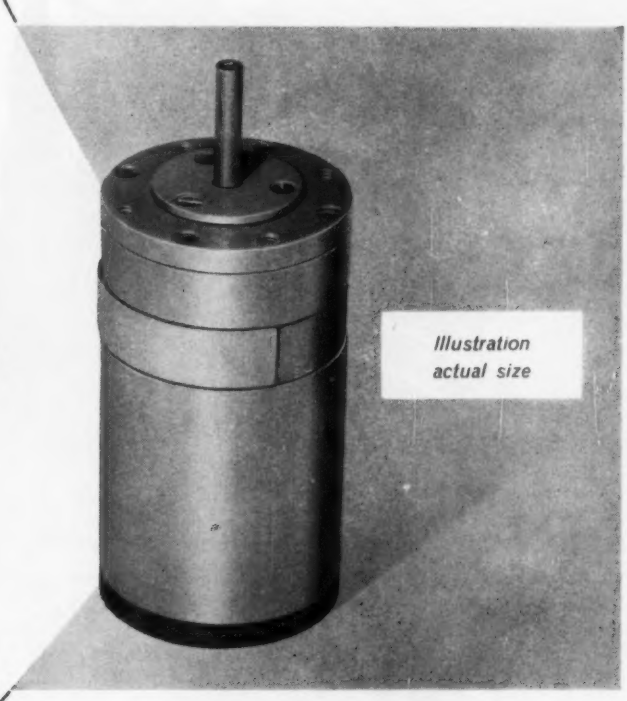


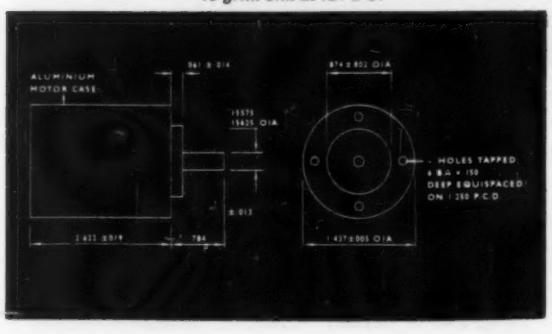
Illustration actual size

For Professional and Scientific Applications

Designed primarily for Professional Tape Recorders this new EMI Battery Motor (part no. 98170D) is also suitable for Television camera remote control, and for medical and other scientific uses. A high-grade precision-built Motor for long life and exceptional speed regulation over a wide range of load and voltage. A Multi-pole Armature gives low electrical interference, long brush life and high efficiency and a Ball Race bearing is incorporated for handling heavy duty side loads.

Provisional Technical Specification

Voltage Range:	8v to 12v DC
Current:	No load 120mA max. 8-12v At 45 gcms 310mA max. 8-12v
Rotation:	Anticlockwise viewed from spindle end.
Speed and Output:	Max. continuous rating. 2440-2500 r.p.m. at 45 grm. cms. torque at 12v DC +0v 2390 r.p.m. minimum at 45 grm. cms. torque at 8v DC −0v Speed regulation over governed range at constant voltage 0.75 r.p.m. per grm. cm. torque. Speed regulation over governed range at constant torque 12·5 r.p.m. per volt DC Max. No load ungoverned 12v No load governed 8v Minimum torque at governed speed 15 grm. cm. at 12v DC.



EMI also manufacture a wide range of inexpensive battery motors suitable for Domestic Tape Recorders, Gramophones, Fans and a host of other applications where a governed torque of up to 10 gm. cm. at 1600 r.p.m. or 2600 r.p.m. is required.

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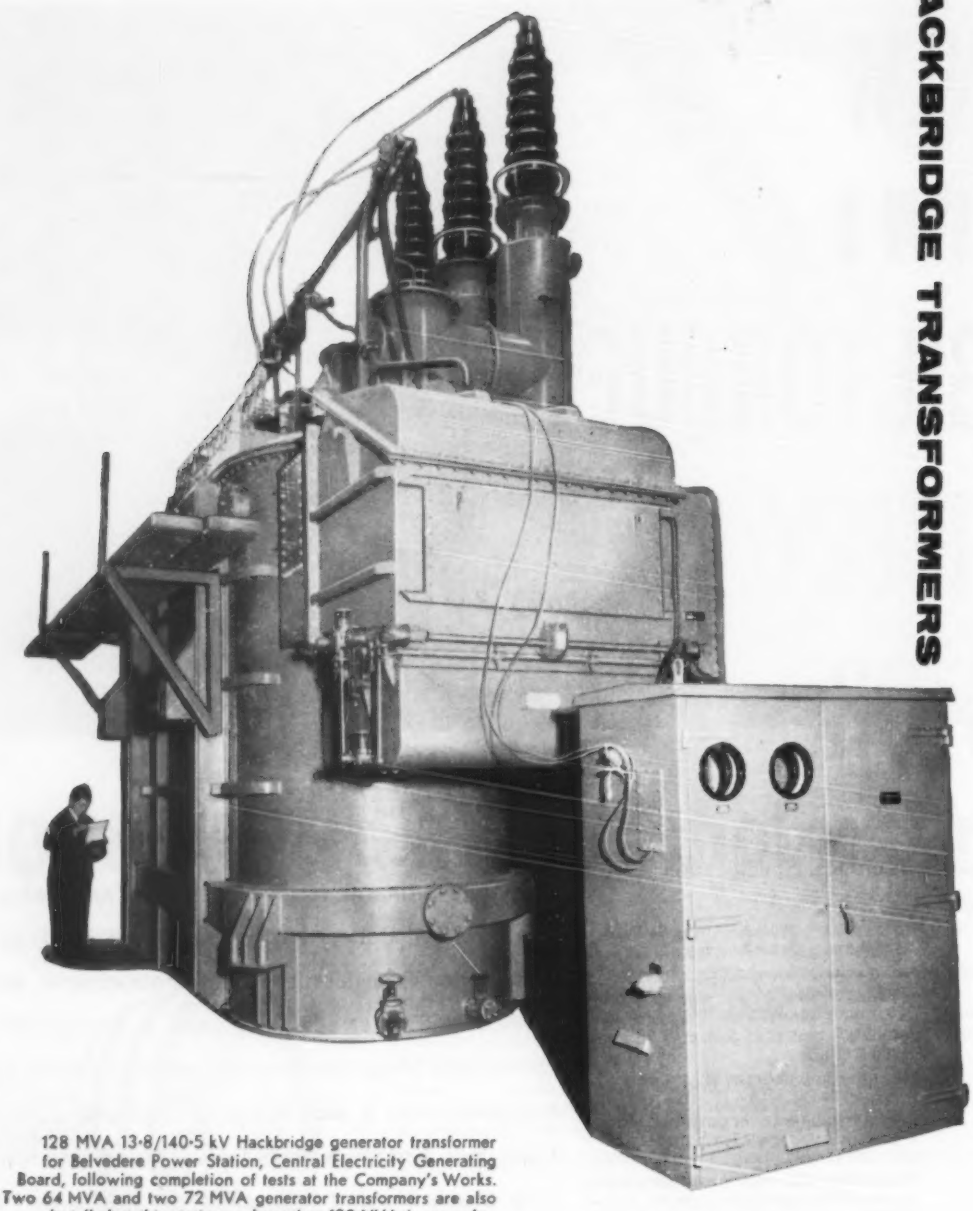

128 MVA 13·8/140·5 kV Hackbridge generator transformer for Belvedere Power Station, Central Electricity Generating Board, following completion of tests at the Company's Works. Two 64 MVA and two 72 MVA generator transformers are also installed at this station and another 128 MVA is on order.

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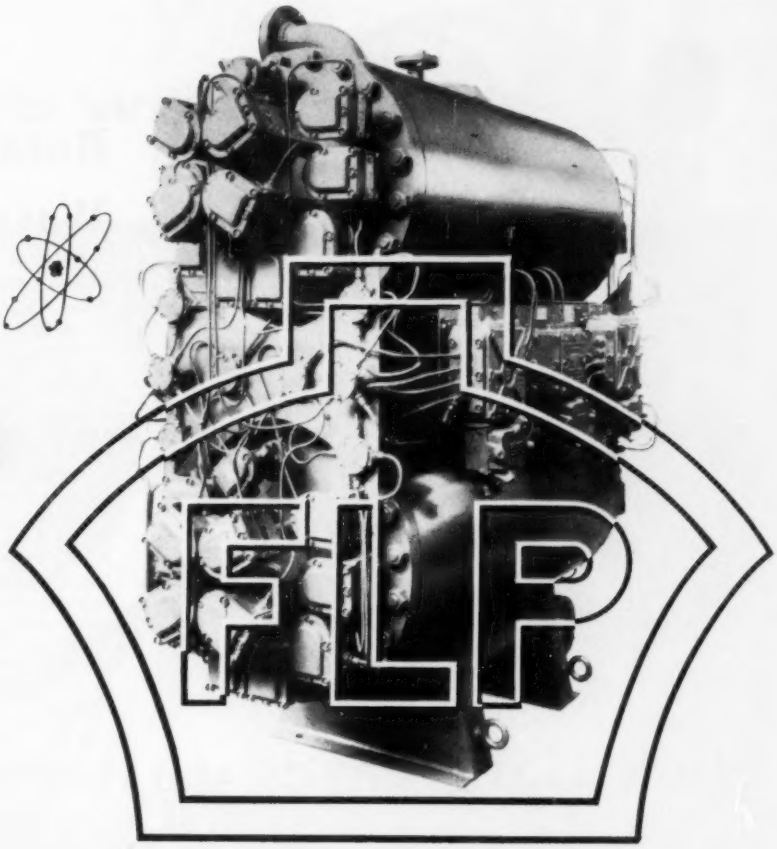

—equipment such as this flameproof high capacity heater for process dowtherm in the petroleum industry. Two such heaters were completed by Heatrae Limited within ten weeks of receipt of drawings. Each unit, weighing approximately 3 tons, consists of two steel pressure vessels connected in series, with a total loading of 160 kW and an operating pressure of 50 p.s.i.g. 48 removable core immersion heaters each positioned inside a steel tube, with Buxton certified flameproof terminal enclosures for gasses in groups II and III are arranged for balancing switching in three stages and are protected by high temperature limiting thermostats.

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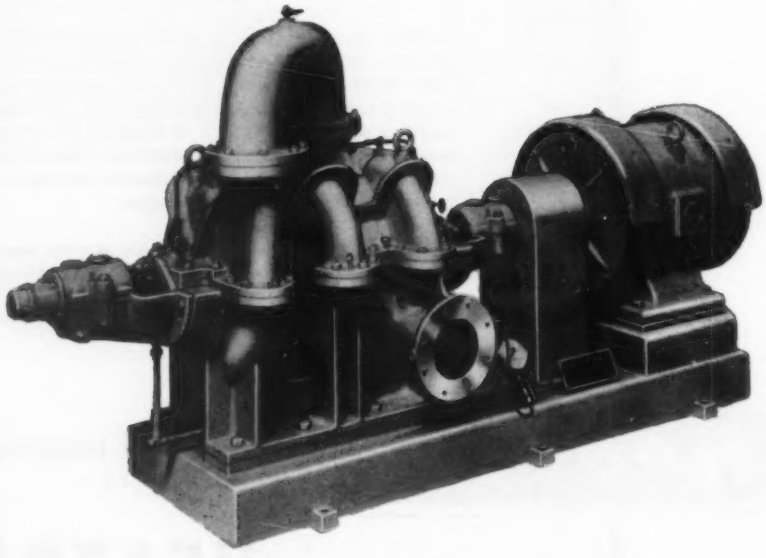

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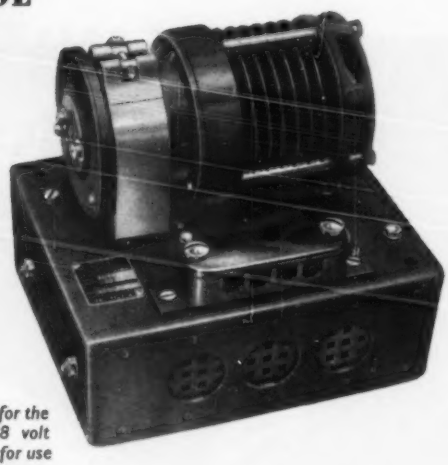

Model shown is for the control of a 28 volt D.C. generator for use on aircraft.

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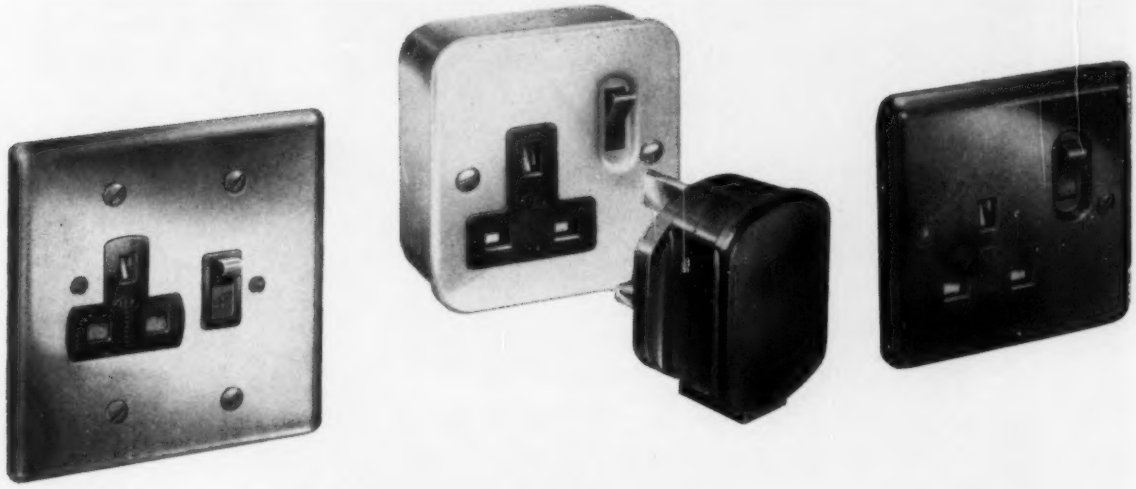

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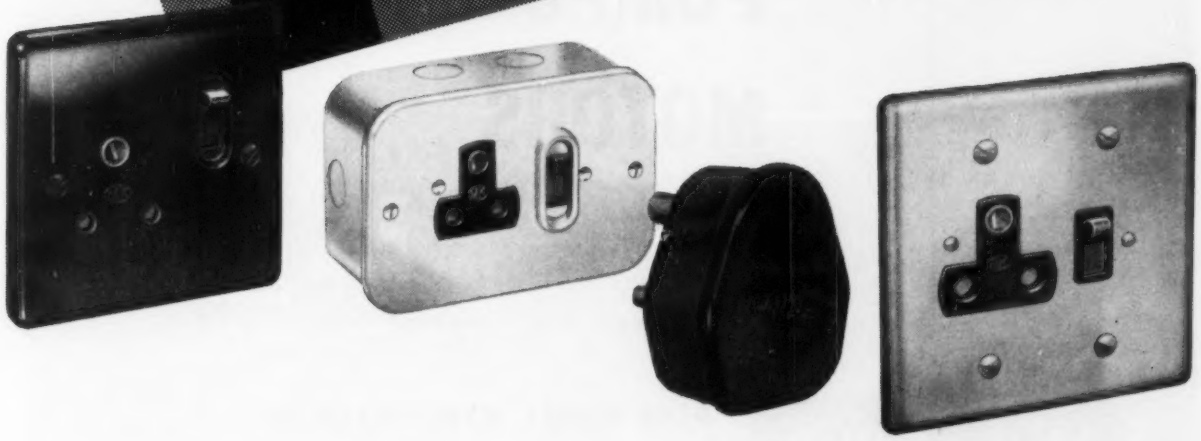

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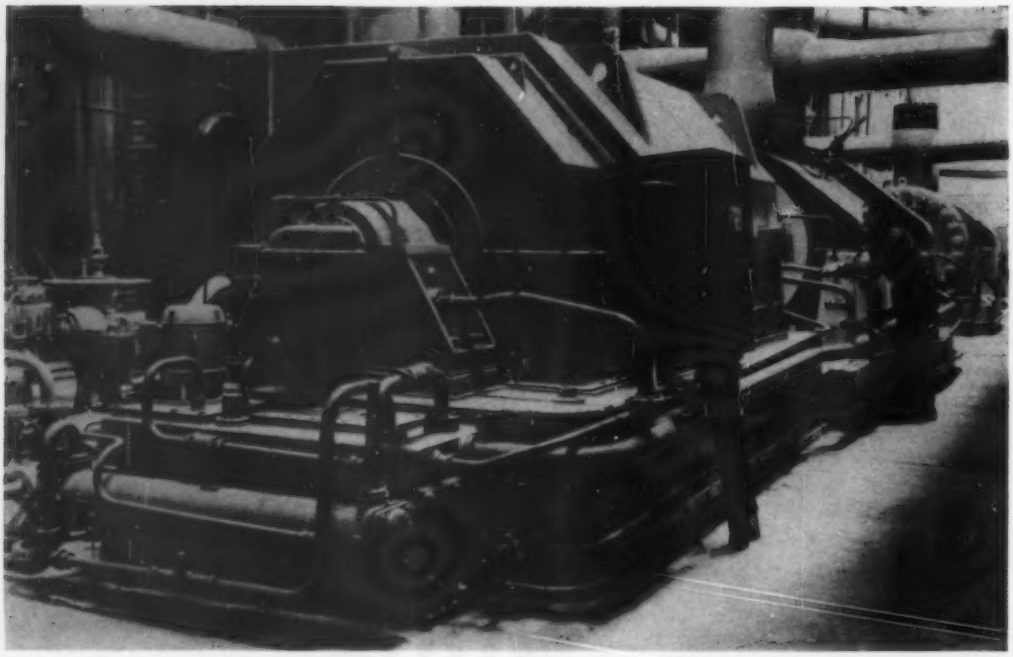

A109

The illustration shows one of ten boiler feed pump sets installed in a British generating station. The pumps are driven by squirrel-cage induction motors rated at 6150 b.h.p. 3000/2976 r.p.m. working from 3 phase, 50 cycles, 6,600 volts supply and the high pressure, high temperature Plurovane boiler feed pumps each deliver 1,550,000 lb./hr. of feed water at a temperature of 470°F, 2852 p.s.i.g. The motors are direct-on started with low starting current.

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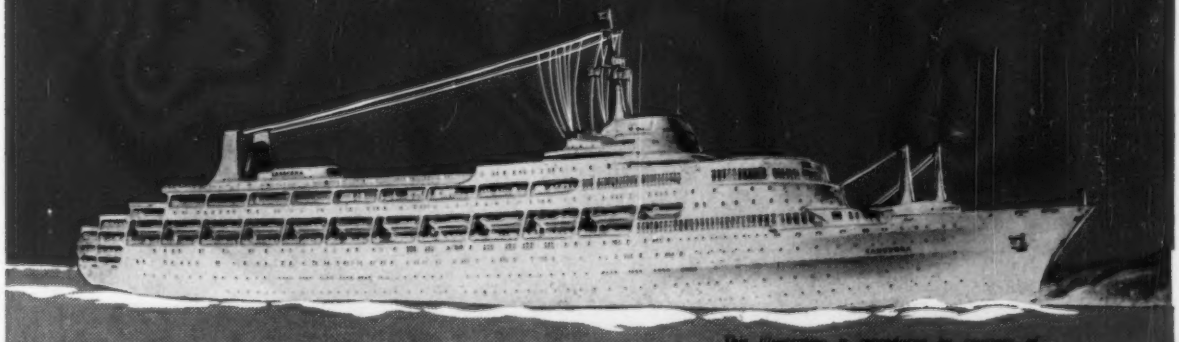

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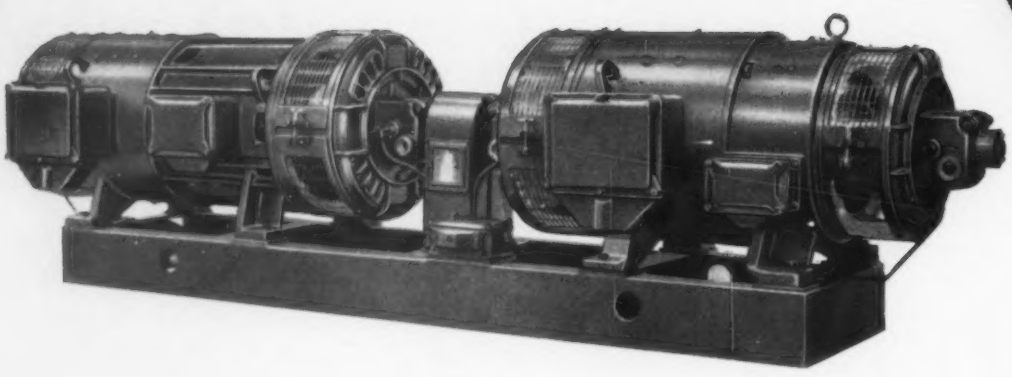

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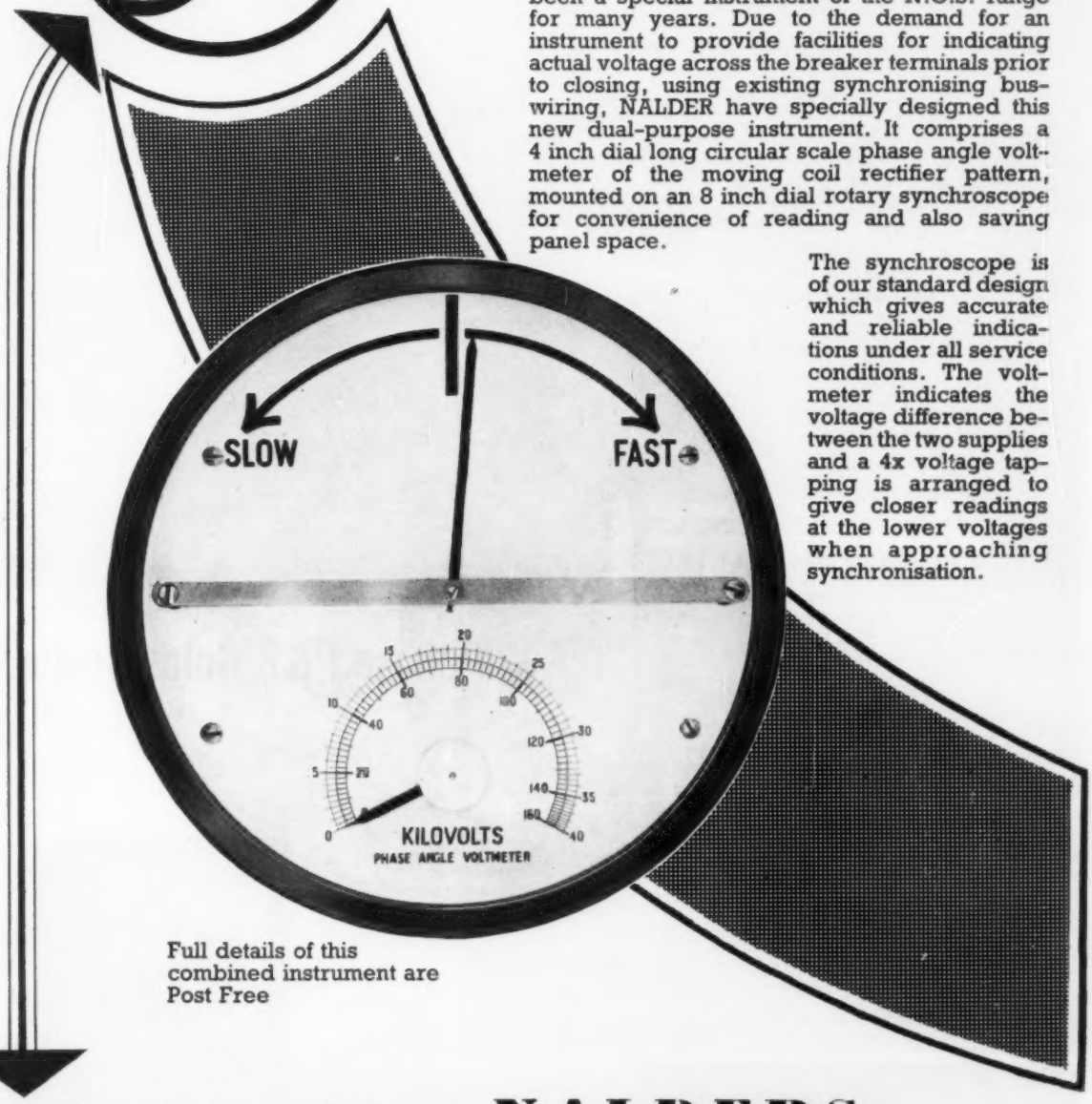

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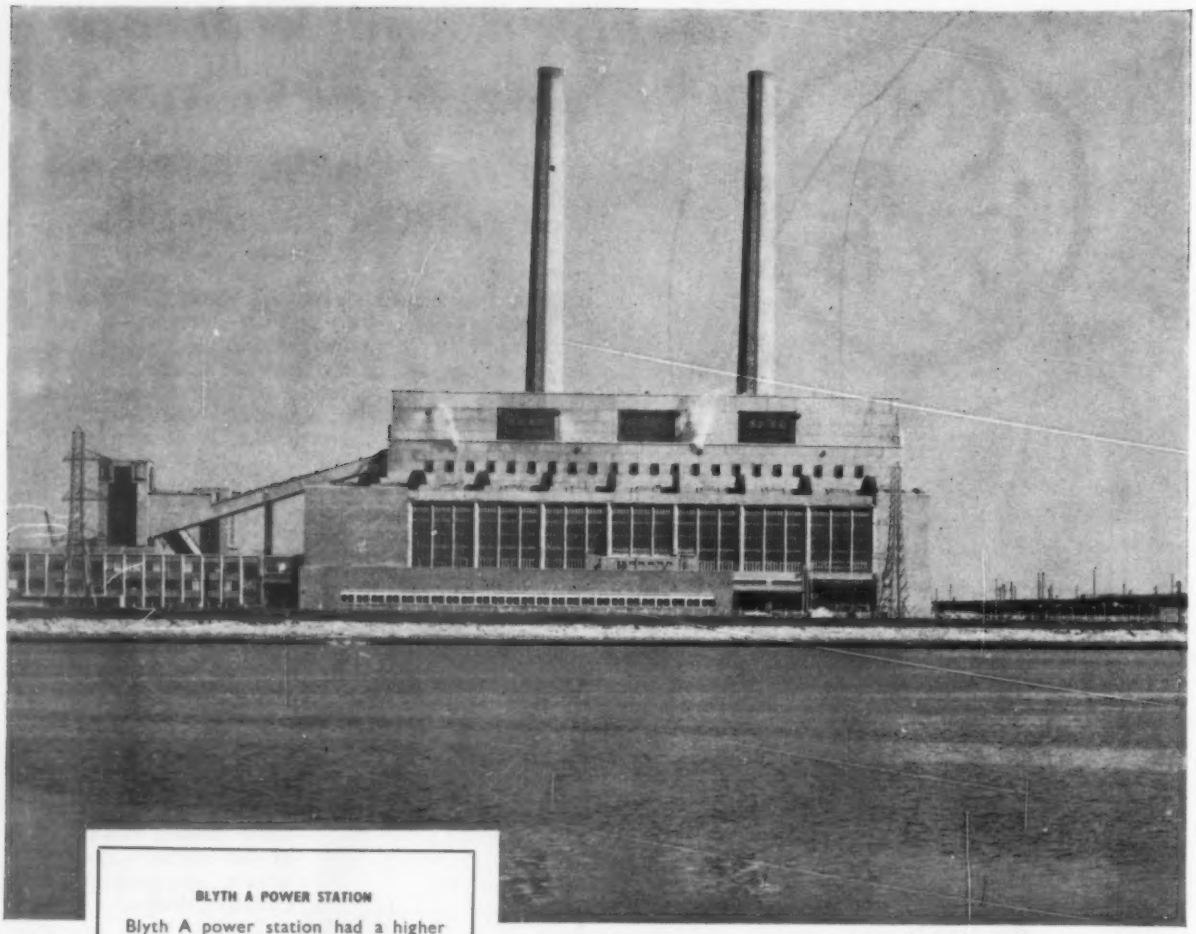

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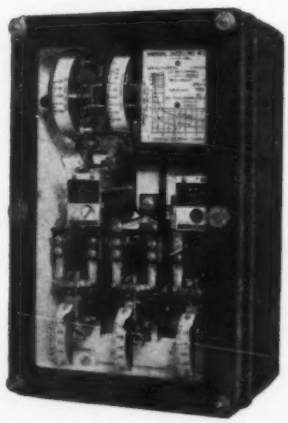

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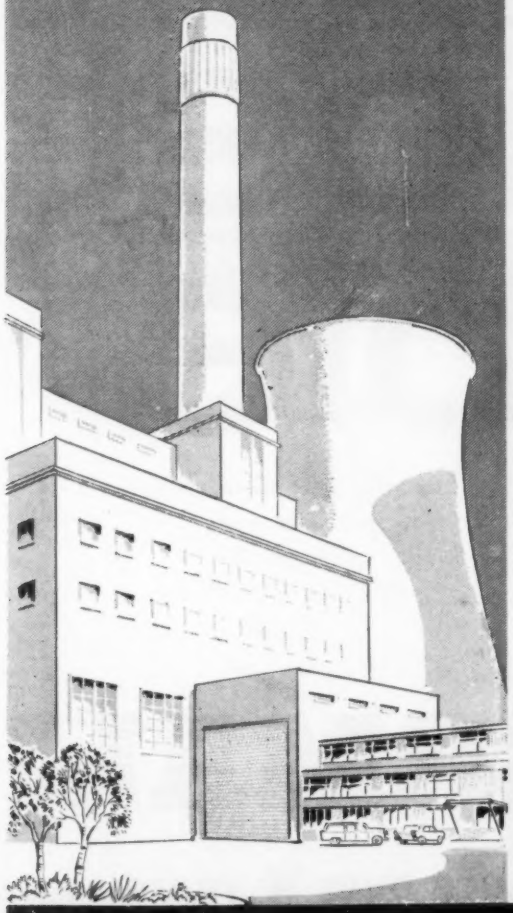
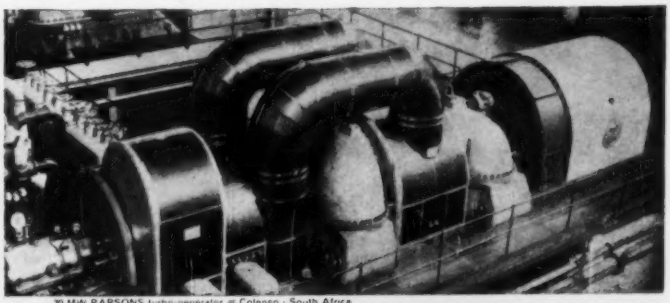
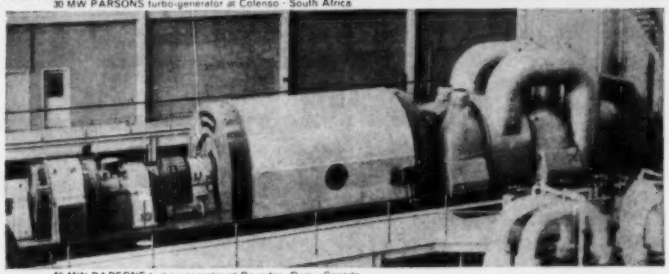
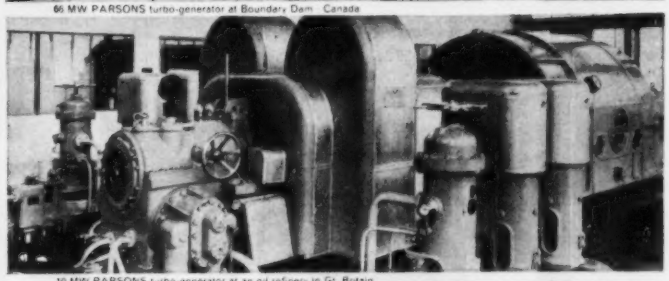




30 MW PARSONS turbo-generator at Colenso · South Africa



66 MW PARSONS turbo-generator at Boundary Dam · Canada



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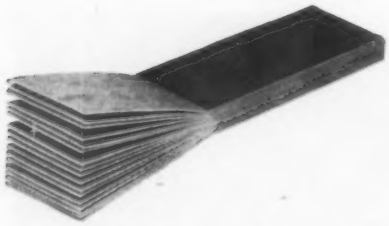

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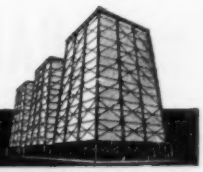

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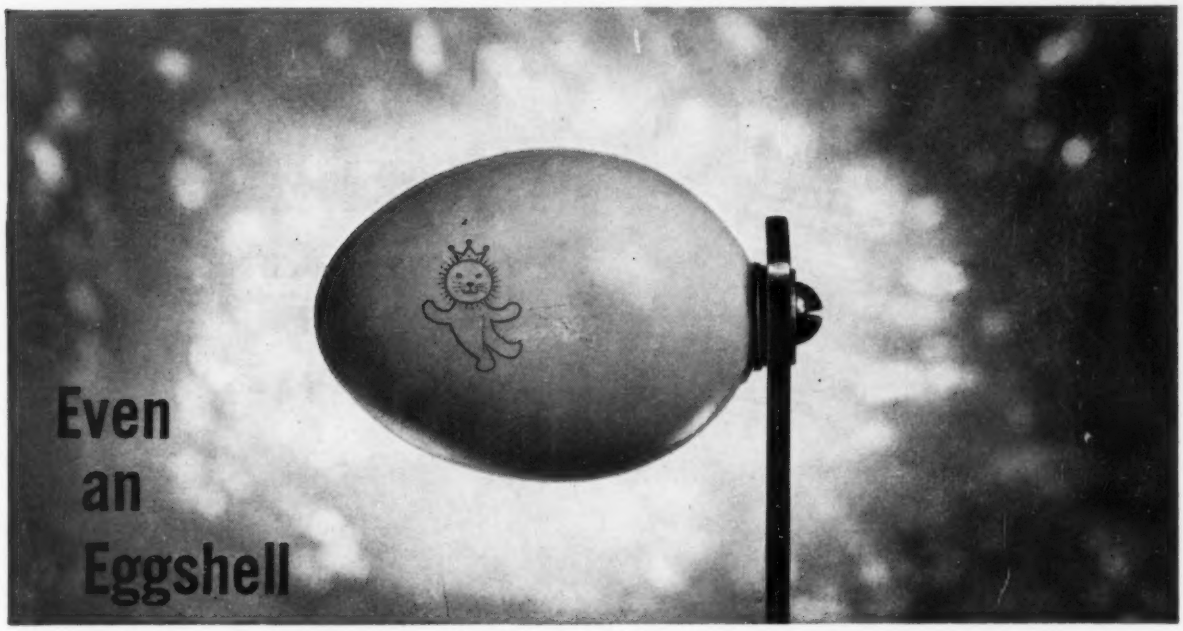

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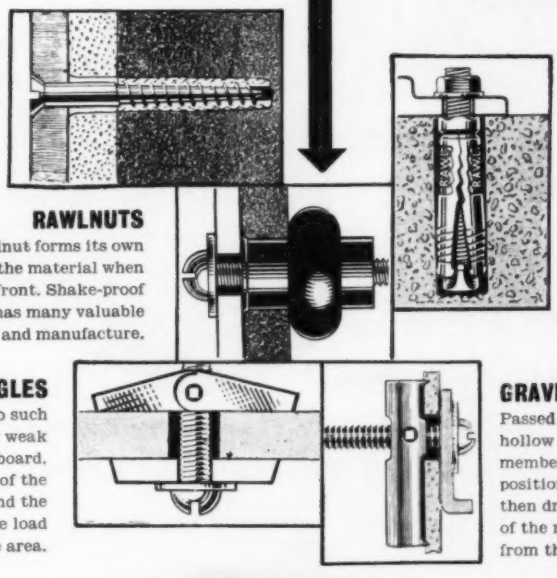

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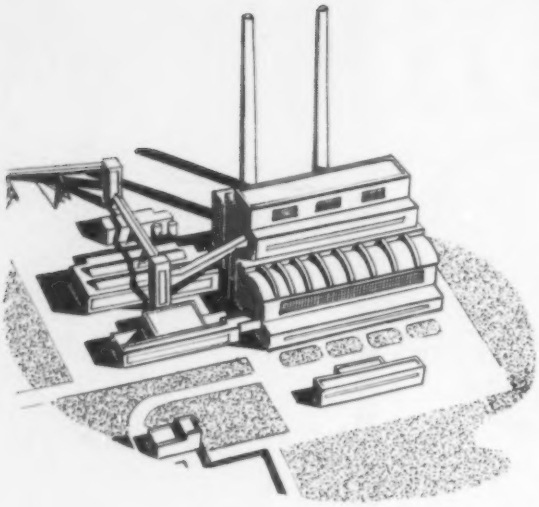

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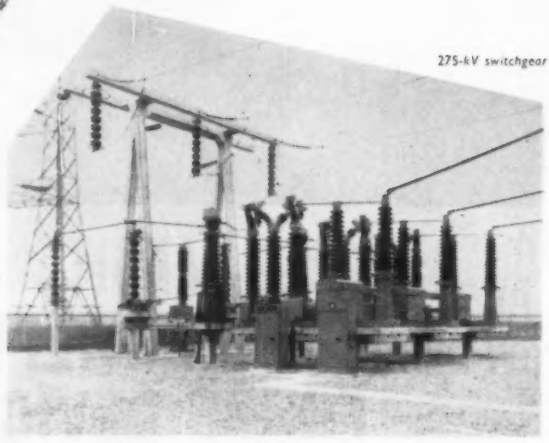

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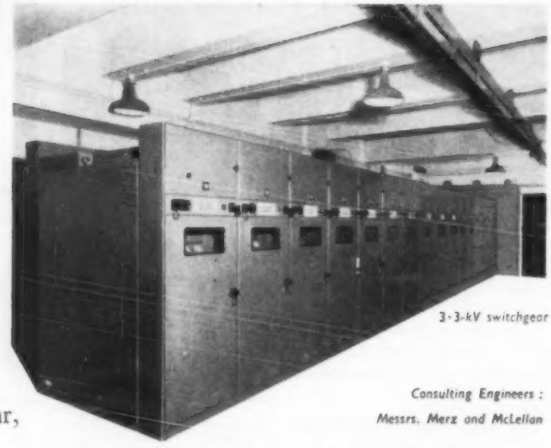

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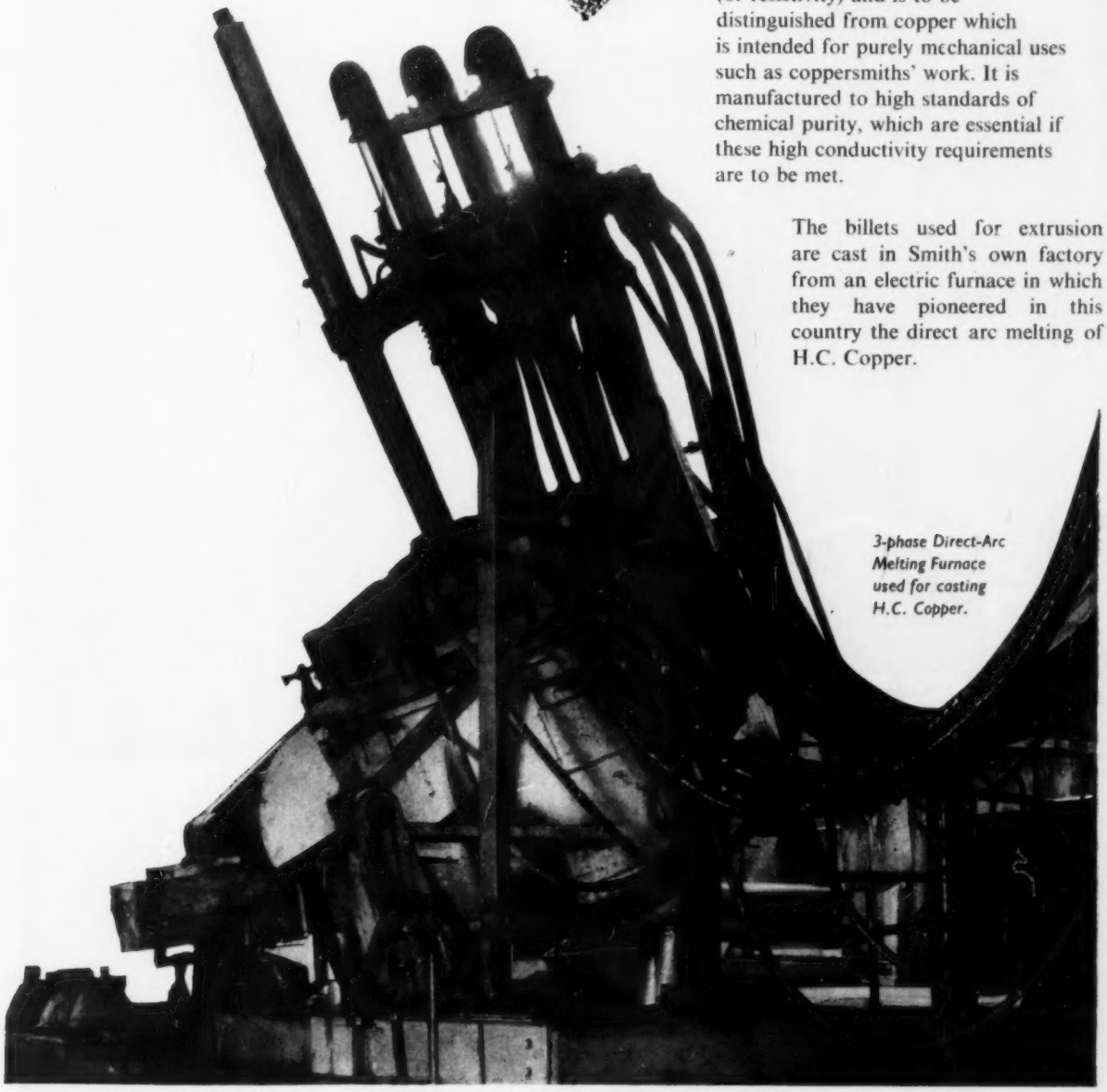

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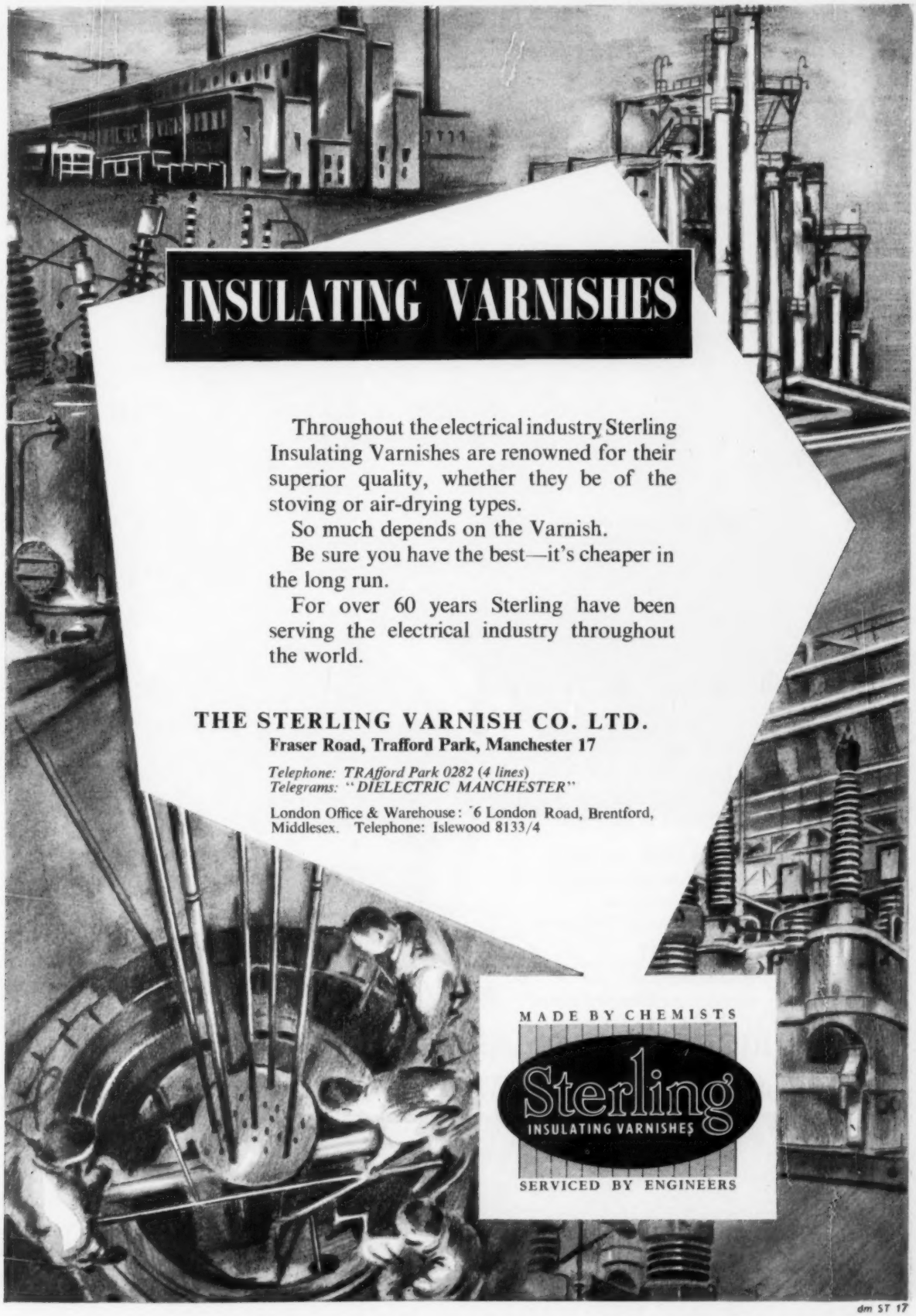
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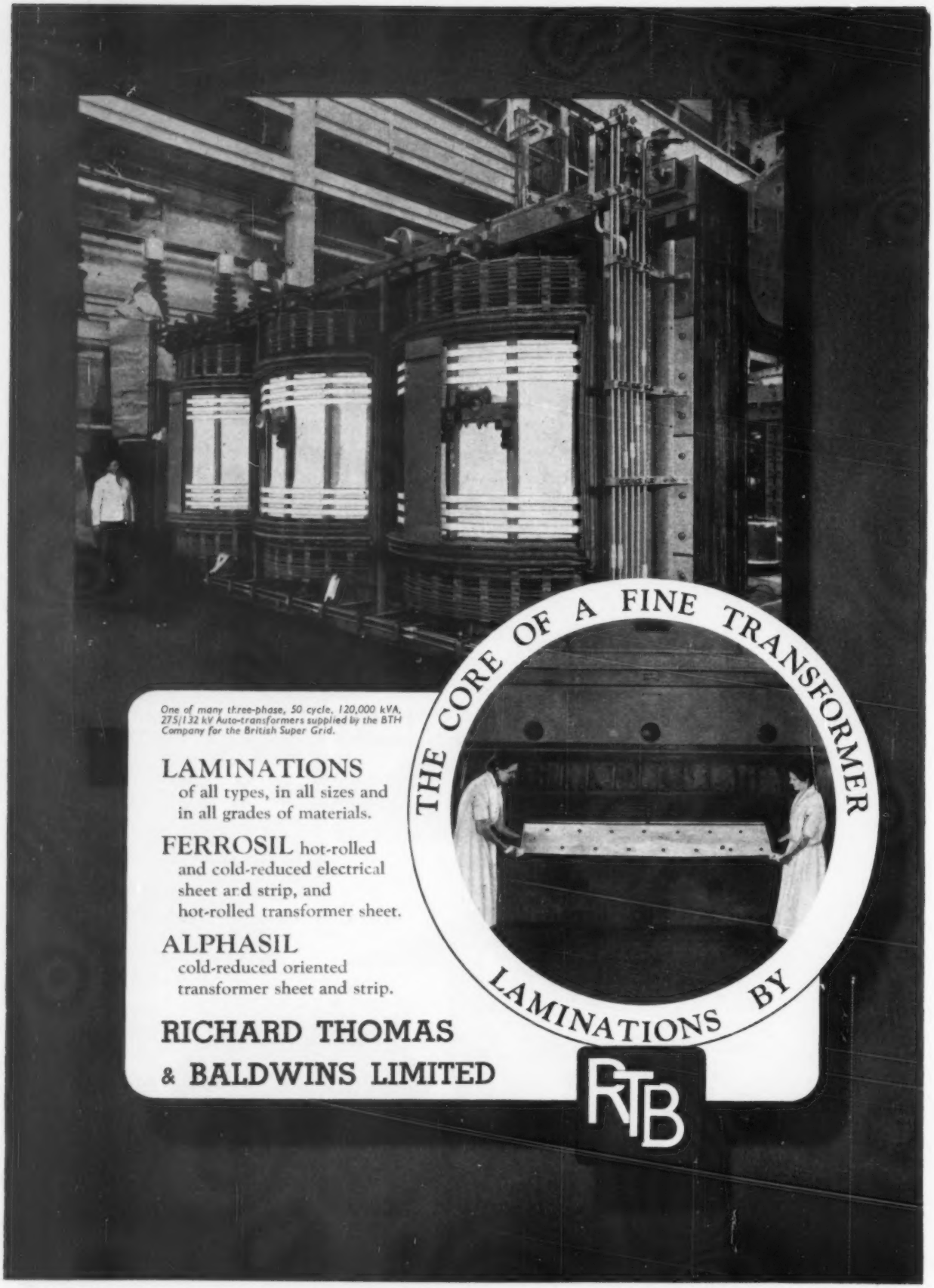

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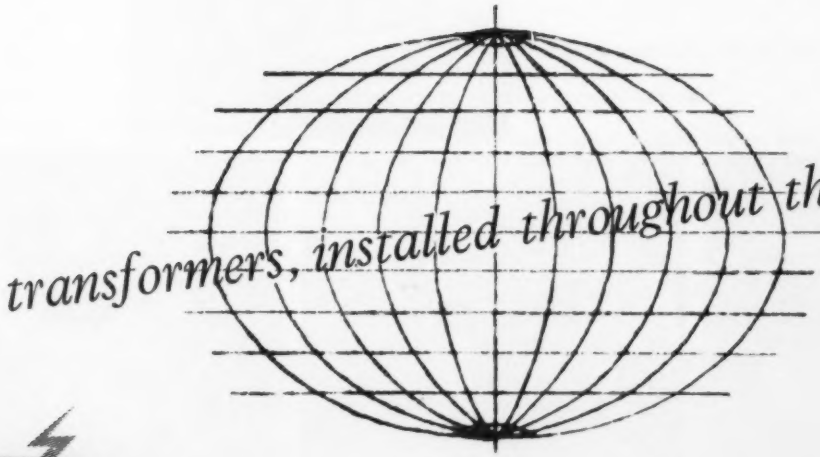

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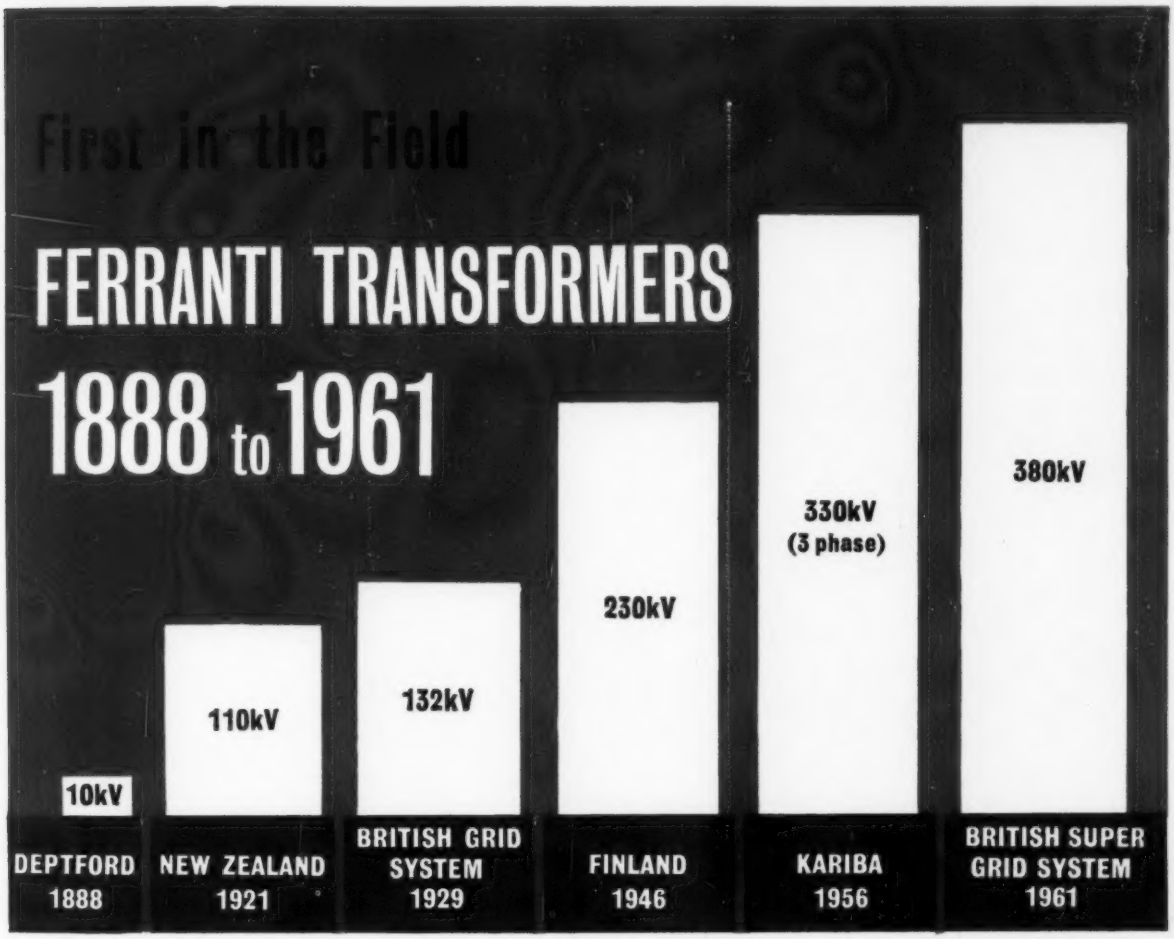

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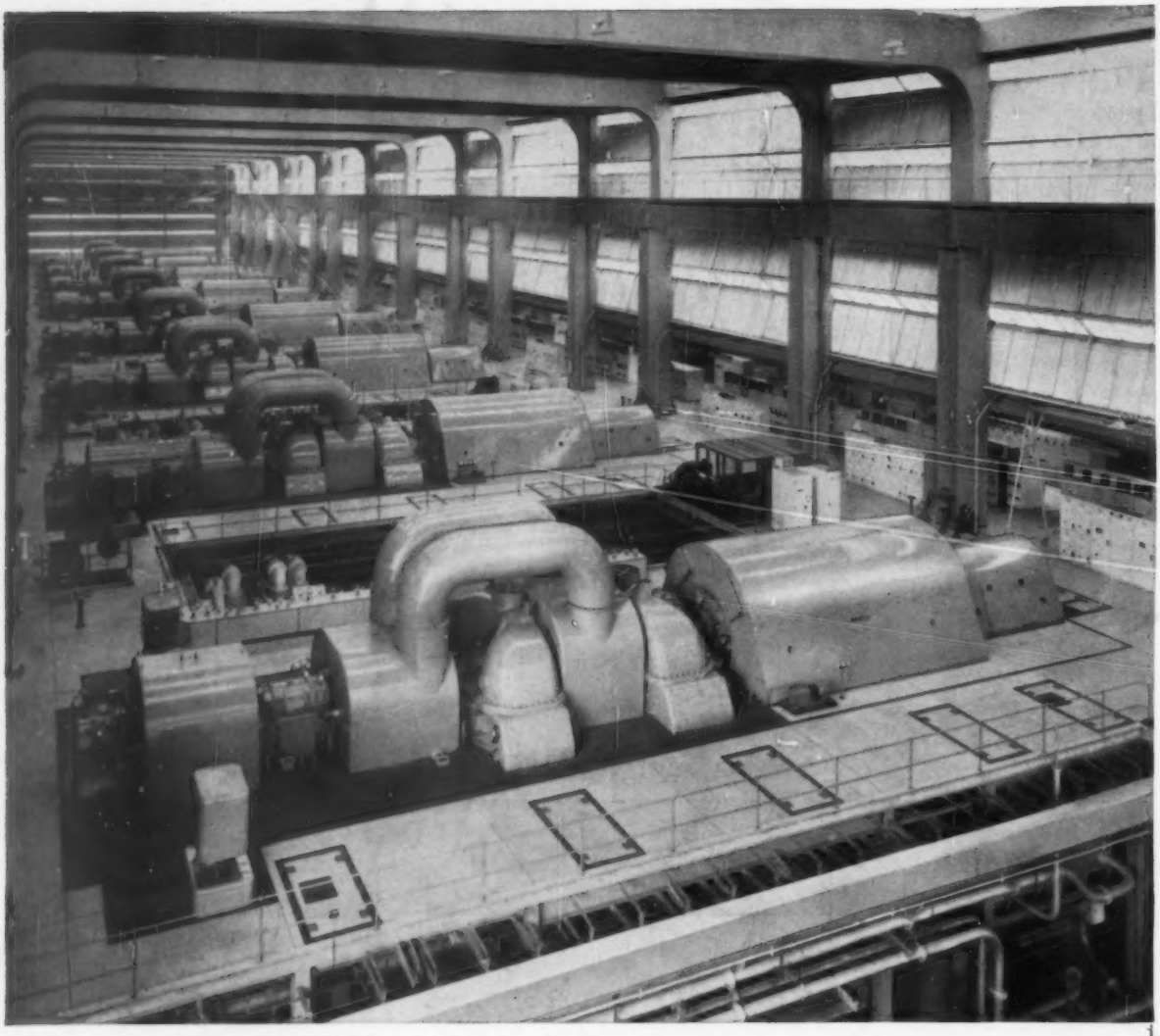

Eight 'English Electric' 60MW, 3,000 r.p.m. hydrogen-cooled turbo-alternator sets at the Marchwood Power Station of the Central Electricity Generating Board. The station also includes 'English Electric' 3·3kV switchgear.

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